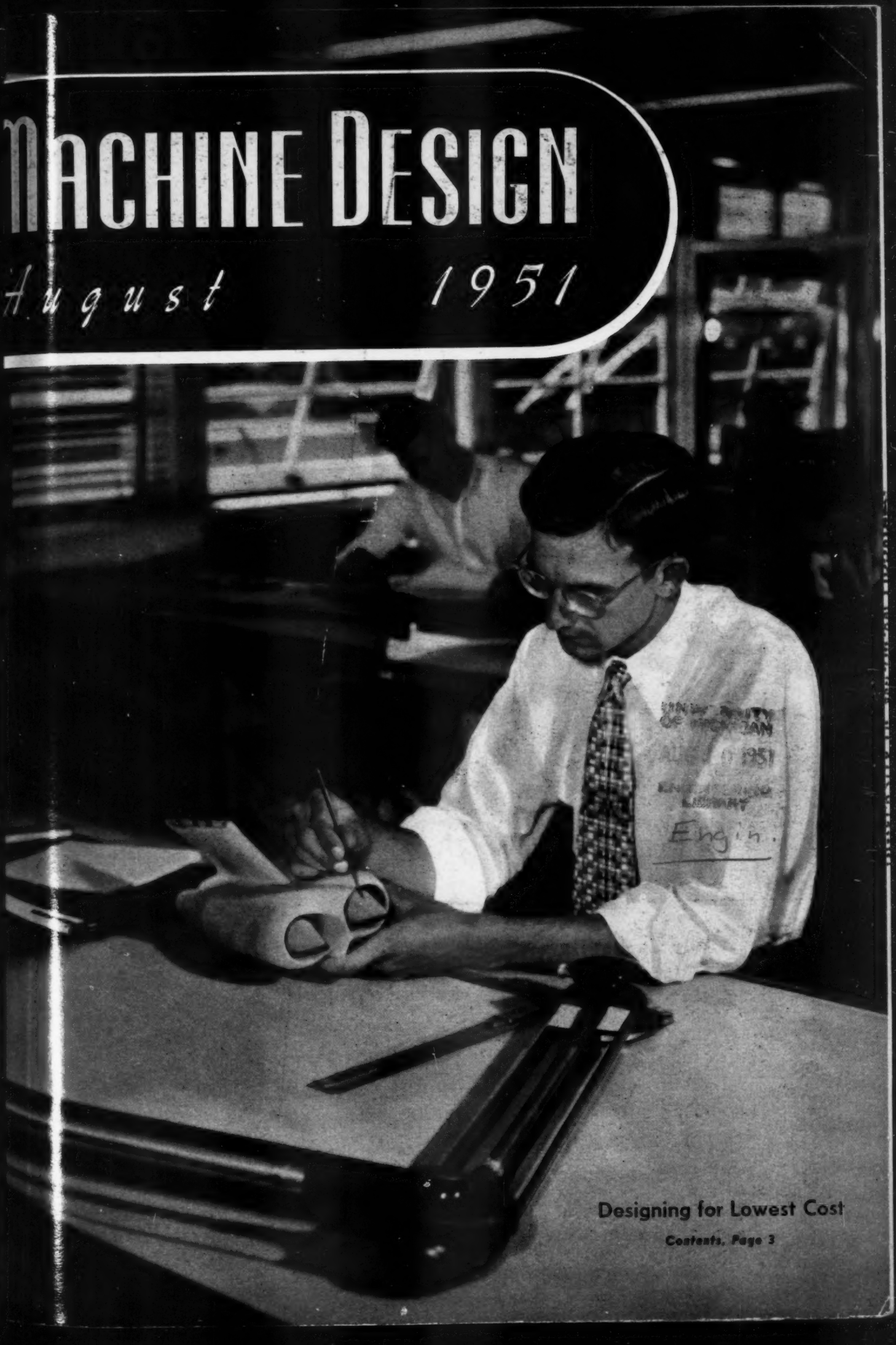
MACHINE DESIGN

August 1951



Designing for Lowest Cost

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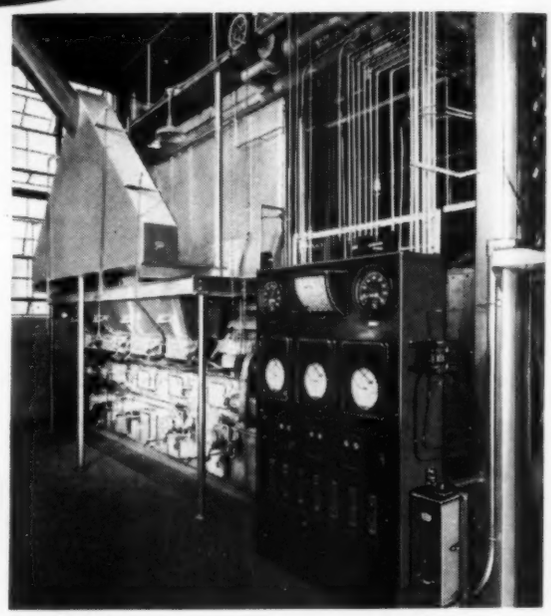

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There is no such thing as a *bad* product of any kind on the American market; competition is too severe for a poor product to exist. But there *are* degrees of merit. Some products are recognized as better than other products. And some few in every field are widely accepted as the *best*. Their makers are acknowledged leaders and their names have become buy-words for assured satisfaction. This position of commercial advantage is neither easily won nor held without a policy of scrupulous attention to every detail influencing product performance in the user's hands. In accepting this obvious fact no thinking person can fail to be moved by the force of the evidence that Cutler-Hammer Motor Control is so frequently and continuously the choice of the nation's leading machinery manufacturers. You too will find it pays to insist on Cutler-Hammer Motor Control . . . . . CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Limited, Toronto, Ontario.

MACHINE DESIGN

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

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Over the Board

CCA

Perhaps the various insignia at the foot of Page 3 have aroused your curiosity. They stand for certain organizations with which MACHINE DESIGN is affiliated in the publishing field. We have already told you about SBME and thought you might be interested in knowing what CCA stands for. The letters are the initials of Controlled Circulation Audit. As most of you know, MACHINE DESIGN is not sold on newsstands, and salesmen do not solicit personal subscriptions. The reason is that with a controlled publication it is the publisher who decides where copies of the magazine are to go. In our case we see to it that at least one copy of MACHINE DESIGN goes wherever there is an engineering design function. CCA is the organization which checks our distribution and provides our advertisers with an audited statement of circulation.

Incidentally, engineering departments these days seem to be expanding almost faster than we can keep up our circulation list. If there is any shortage of copies in your department, won't you please drop us a line?

This Month's Cover

Seeking a cover picture to portray the theme Engineering for Producibility—the subject of this month's special feature article—we were attracted by a photograph of an engineer at work, offered us by the Boeing Airplane Co. The four-color process cover you see shows Boeing engineer Robert Marhefka studying a twin jet-engine nacelle for a wind tunnel model of the B-47 Stratojet. The picture, we feel, fittingly symbolizes the tie-in between performance and producibility.

Evolution of a Brainchild

It is easy to become so absorbed in the details of a job that we lose sight of the woods because of the trees. Take the broad problem of designing a new machine from scratch. How often do we take time to look at the picture in full perspective? In this issue J. M. Wallace has done just that (Page 102). His article, however, posed a problem for the editors —how to illustrate so general an article. The best answer seemed to lie in a series of sketches picturing steps in the procedure or the thought processes of the designer. The drawings were conceived and executed by Penton artist Ed Drozdz (rhymes with rose).

Return Postcards

Previously we've mentioned the popularity of the return postcards for requesting copies of articles. This service has attracted many of you—in fact, we are still swamped by the deluge of returns prompted by Randolph Chaffee's June feature, "Evaluating Engineers."

As you can well imagine, we've had to mechanize this service for speed and economy, foregoing the pleasure of personal attention to every request. But occasional unusual uses of the return cards do attract extra attention. For example, last month two cards arrived in the same mail, one requesting "all articles for filing purposes," the other "all articles for future reference." We were flattered, but at the same time were reminded of a request from a Texan who wanted "everything you have on engineering."

We want our readers to use the service and hope that all will exercise the discrimination shown by most in selecting only specific titles. Copies then will go where they are most needed—and our distribution mechanism will function smoothly.

Torque Converters

Usually we think of a fluid torque converter as a luxurious convenience for automotive transmissions. In Ray Orton's article, Page 113, successful application of this type of unit is discussed as a sturdy, dependable and flexible transmission for heavy-duty locomotive cranes. A tail-shaft governor on the output shaft of the converter solved the inherent variable-speed problem. In this way the diesel engine drive "floats" over a speed range, giving controlled output speed and torque as required by the loading. Due to reduction in shock loading, capacity of the machine is increased and maintenance decreased.

Teaching Machine Design

Practicing engineers who suffered under old-style machine design courses in engineering schools will be happy to know that the rising generation is getting a much better break. For instance, at the University of Minnesota a couple of enthusiastic professors, J. J. Ryan and E. N. Kemler, are instilling something of the breath of life into what has traditionally been a dull course. Drafting and paperwork are giving way to studies of actual machines and mechanisms in a machine design laboratory. The results should pay off in increased interest in machine design as a career, as well as a better preparation for practical engineering work.

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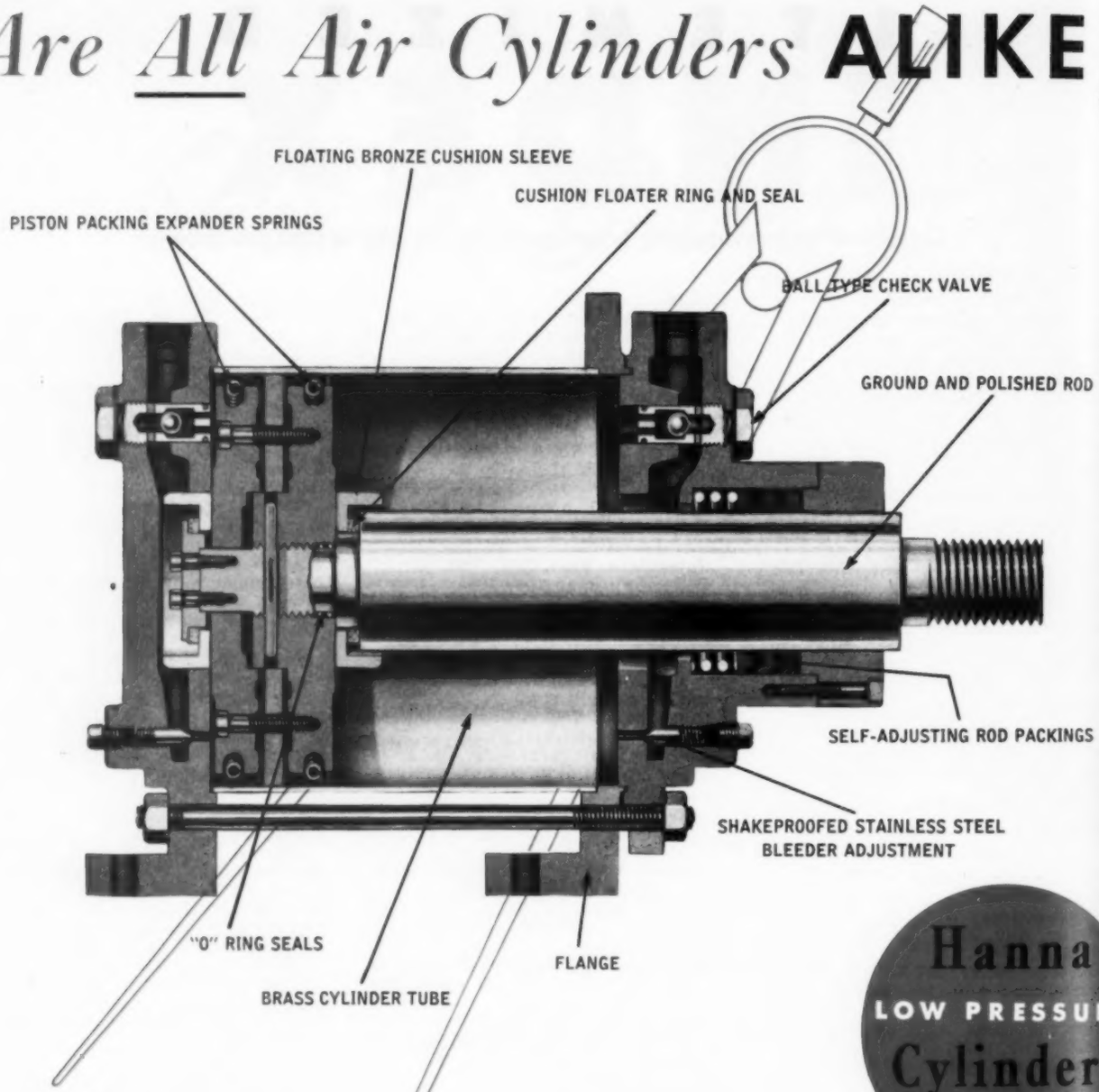
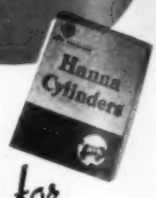
Are All Air Cylinders **ALIKE?**



Hanna LOW PRESSURE Cylinders



Not when it comes to cushion sleeves, flange design or the packing of pistons and piston rods. Each of these elements of the Hanna low pressure cylinder provides special benefits for you. Notice the expander springs which insure uniform contact of piston packing with cylinder; the cork floater ring facilitating cushion alignment with head and insuring a seal during cushioning; the spring-backed chevron rod packings, self-adjusting for consistently correct compression; the flange design permitting removal of front head without disturbing mounting. These Hanna-engineered features are refinements resulting from fifty years' experience in design and application of pneumatic and hydraulic equipment. To you they mean increased efficiency—decreased maintenance.

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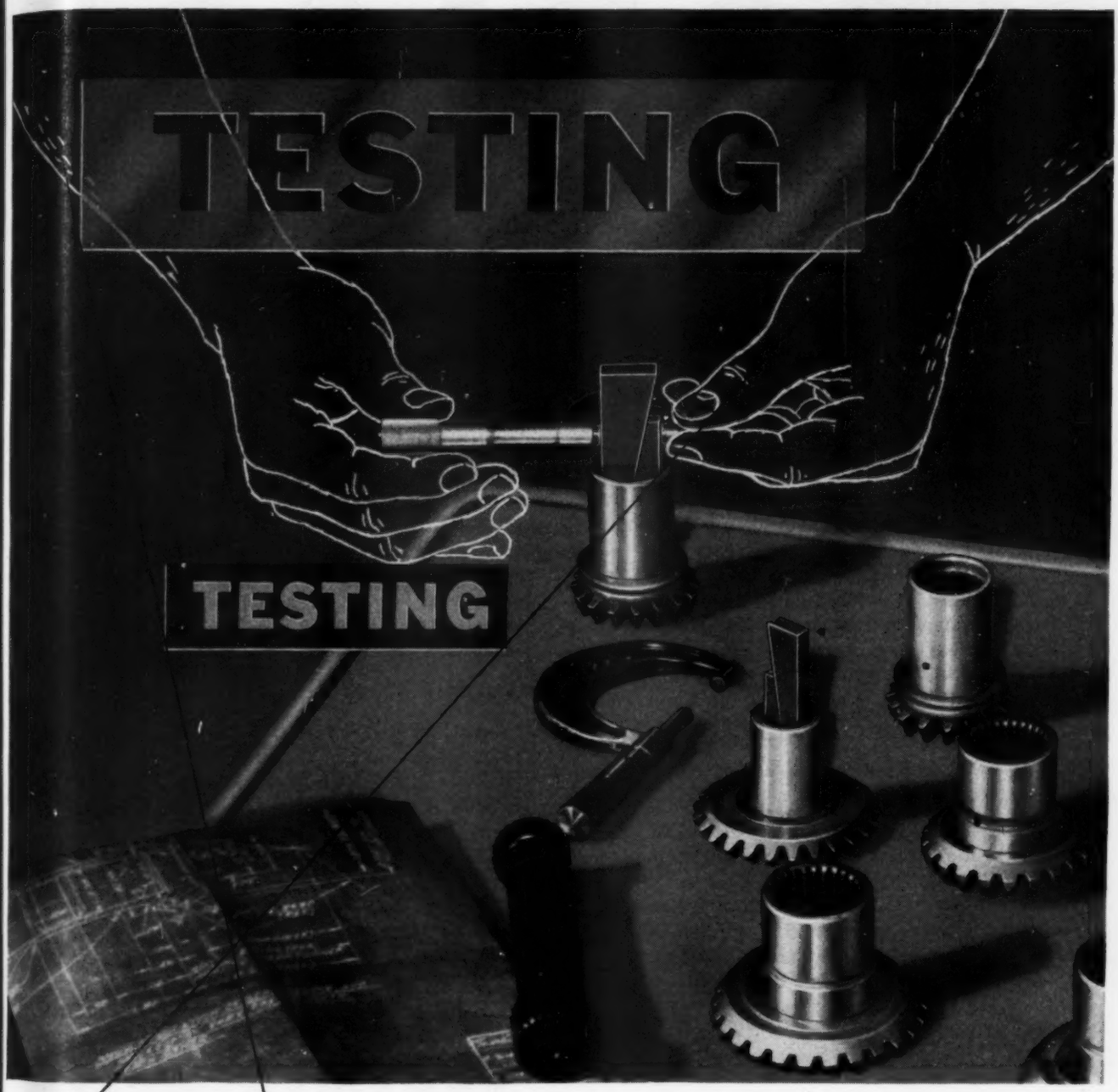

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TOPICS

WING SWEEPBACK ANGLE can be varied in flight on the turbo-jet powered Bell X-5 airplane. Now being tested by the Air Force, the jet plane contains a mechanism which simultaneously varies the angle of wing sweepback and compensates for shift in center of gravity.

FIRE-FIGHTING FOG can be produced with ordinary garden hose and a gun type nozzle available from Bete Fog Nozzles Inc. Water fog is generated at pressures of 30 to 120 pounds.

NUCLEAR POWER is not yet the answer to power production problems. The installed cost of a nuclear ship-propulsion reactor would be $1400 per kilowatt-hour, according to L. R. Hafstad of AEC, as against $133 for conventional equipment.

LOW-TENSION SPARKING can ignite leaner fuel mixtures, resists fouling better and can be used at higher altitudes in aircraft engines than conventional high-tension sparking, according to a report from Holland by W. Beye Smits. Using flush-gap spark plugs and a special capacitive ignition system, the low-tension method will efficiently ignite almost any fuel, from bituminous fuels, such as tar, and diesel fuels to those with high tetraethyl lead concentrations.

EXPLOSION-BULGE method is used by the Navy to conduct structural model tests of heavy welded steel plate. Specimens, bulged by an explosive, provide basic information on weld deformations and fractures.

LIGHT-WEIGHT HELICOPTER can be folded and loaded on a jeep by two men. The one-place craft under construction at American Helicopter Co. is jet-powered.

FURNACE SCALE REMOVAL is simplified in a process announced by the Pennsylvania Salt Mfg. Co. Forgings are dipped in a newly developed chemical bath before heat treating. When forgings are water-quenched, the iron oxide scale drops off the surface, leaving it clean for subsequent machining. Oil quenching produces similar results, and in cases where scale removal is not complete, a minimum of sand or shot blasting is needed.

X-RAY GAGING of hot and cold-rolled strip gives more accurate thickness control and higher rolling speeds according to W. A. Black of Republic Steel. No mechanical contact with the metal is necessary.

ARTIFICIAL MOUTH tests telephone handset transmitters at Western Electric. A loudspeaker unit produces a signal which swings 15 times per second over the voice-range sound band of 600 to 1600 cycles. The test takes about five seconds.

RICE GRAINS, forced at high speed into automobile-engine combustion chambers, effectively clean out carbon without the necessity of tearing down the engine. An air jet produced by the Kent-Moore "carbon blaster" blows 5½ ounces of rice into each cylinder. The rice is then exhausted and filtered for reuse.

PLASTIC INSULATION is pressed onto wire in powder form by shaped grooved rolls in a new Du Pont experimental method. The wire is then baked to fuse the particles. Developed for applying relatively thick layers of Teflon, the process can be used to coat a number of wires simultaneously.

XERORADIOGRAPHY, an electrostatic process for obtaining direct x-ray prints, uses low-cost powders instead of conventional films and chemicals. In less than two minutes an x-ray negative picture is obtained, making the process fast enough for use in industrial inspection.

PORCELAIN ADHERENCE to metal is determined electrically by measuring the area of exposed metal on a deformed test specimen. A meter, developed by the Porcelain Enamel Institute, uses a large number of test probes to contact the test area. Since porcelain is an insulator, a count of the number of probes conducting a current gives an indication of the amount of porcelain still adhering to the metal.

MACHINE DESIGN
A PENTON PUBLICATION

Mobilizing for Lower Cost

IT IS no reflection on the competence of design engineers to say that there isn't a machine in production today that could not be built at drastically lower cost through intelligent redesign. Rather, it is a recognition of the fact that design for producibility, as a science, is in its infancy. It may be argued that machinery manufacturers have always been in business to make money and costs have always been important. But the organized, scientific approach to cost reduction *through design* is relatively new, though it has been gathering momentum in recent years.

We are not referring to the streamlining of production methods that has been going on for years—through faster machine tools, stamping operations, mechanized casting and forging processes, etc. We mean the bold, imaginative approach to design that combines, for most effective results, the two P's of engineering design—Performance and Producibility. This approach usually requires complete reanalysis of performance and a refusal to be unduly influenced by past history in the making of typical parts. It requires, on the other hand, a comprehensive knowledge of production processes and an understanding of where they fit. As an important side effect, the resulting competition has powerfully stimulated the protagonists of particular methods or processes to make improvements that have advanced the art and science of working materials.

During the most intensive years of this development MACHINE DESIGN has been a leader in promoting better design for producibility. Through contributed articles, and particularly through the extensive series by associate editor Roger Bolz on *Production Processes . . . their influence on design,* the profession has been given a wealth of factual data and a design philosophy which, we believe, has contributed materially to cost reduction through design.

In the special article by Mr. Bolz which appears in this issue there is unfolded a plan of action through which engineering departments can mobilize for effective savings where basic costs actually are established—in design. We commend it to the earnest attention of engineering executives.

Colin Carmichael

EDITOR

Designing a New Machin

Steps in the engineering procedure of developing a successful machine from the first conception or general idea

By J. M. Wallace
Engineering Manager
Distribution Apparatus Section
Westinghouse Electric Corp.
East Pittsburgh, Pa.

PROCEDURES in designing a new machine are pretty much the same whether it is a household appliance or a tractor. This article will attempt to outline these procedures in an orderly and logical sequence viewing the problem only in its broadest aspects.

At the outset the need for a new machine is brought to the attention of the designer in a number of different ways. Perhaps the sales department will point out that a competitor is far ahead on such and such a point and that engineering should do something about it. Sometimes a request for a new and different product comes in from the field. Occasionally a fundamental idea discovered in the research laboratories will be found to have commercial possibilities. Then too, a designer may have an original idea for a new product and set out to work on it. Regardless of the origin, however, the subsequent procedures are just about parallel.

PROJECT INITIATION: The first step is the writing of specifications. The uninitiated may well ask how a specification for a nonexistent machine can be written, but a competent designer recognizes that a number of facts are necessary before a start can be made. Some of these are:

1. Description of performance
2. Size and weight limitations
3. Cost requirements
4. Normal operating ratings
5. Overload operating requirements
6. Special performance characteristics
7. Necessary personnel safety considerations.

Once a design specification has been written, it is well to review it critically—as though a major competitor has written it. With a bang-up specification that will be difficult to improve, the whole project should be submitted for approval of the sales department and the engineering department managers. It is possible, after all, to design something totally unsuited to the job owing to misinterpretations or changes in requirements after the initiation of the project.

PRELIMINARY DESIGN: After the designer has satisfactory and acceptable specifications, the problem is

" . . . he should inspect the work being done in the shop, to make sure that the units are being produced as intended . . . "

to evolve a practical design that will fit. In order to find a suitable answer, the designer must understand the problem. Crystallizing the problem is one of the main purposes of design specifications. Usually the problem consists of an idea which requires answers to numerous smaller problems before proceeding. There is no direct road to the solution of these unknowns but often the answer can be obtained from examination of similar and related problems previously solved. It is for this reason that the designer must take a vital interest in all sorts of machinery, from kitchen appliances to jet aircraft. It is this background of experience on which the designer relies heavily for practical answers to design problems.

". . . the designer must take a vital interest in all sorts of machinery . . ."

Although there have been a number of books written on the subject, the actual method used in solving a design problem is one which cannot readily be put on paper. Apparently, though, the designer must saturate himself with the requirements of the problem and then at some odd moment—when shaving or waiting for the bus—he has a flash which seems to be the answer. As he follows through the workings of this new machine, which he has sketched out in rough form, he finds that for some reason it doesn't work and he realizes that here is an aspect of the design specification which was not anticipated. Quite often this is the case and every time the designer comes up with a solution which is not workable, a new phase of the problem is brought into the open and can be written into the specifications.

Oddly enough, there seems to be some quirk of the mind that makes it come up first with the most complicated solution. For some unknown reason, the complicated solution seems to be the simple one to derive and, the more work put on the problem, the simpler becomes the answer.

PRELIMINARY LAYOUT: After a workable design has been developed and sketched in detail, it can be turned over to a draftsman for a comprehensive layout. It is important that the designer eliminate any fatherly feeling for his own ideas and be willing to accept suggestions from draftsmen and other associates. If the designer realizes that he is trying to obtain a good design and that his reputation will depend on

the design, not on who designed it, he will retain an open mind to accept and consider all suggestions.

A number of factors must be kept in mind during the layout stage in order to produce a practical design:

1. *Redesign for simplicity and practicability.* Only by redesigning the preliminary idea over and over again can a good, workable design be produced.
2. *Use standard practice wherever possible.* Economy is best served if tools which are now available can be used and if special-purpose equipment is not necessary.
3. *Employ standard materials.* Actually, an off-standard material or part is not really necessary very often. Many times, a little extra work will save the purchasing department a headache.
4. *Keep size and weight at a minimum.* Size and weight have a distinct bearing on cost and machine components often are excessively costly on a pound basis. By the pound, an automobile is one of the cheapest things that can be bought because, even on today's market, the cost is considerably less per pound than butter. Generally, machines of a similar nature cost about the same price per pound and, consequently, where size and weight can be reduced, important savings can be effected.

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TESTING THE MODEL: Tests should be planned in advance to give all required information at a minimum in cost. The law of diminishing returns certainly applies to tests and many times an accurate test is demanded where a yes or no answer would be sufficient. Often, one particular test is crucial and should be performed first. There is obviously no point in making radio influence voltage tests on a circuit breaker which will not interrupt the circuit. In setting up a series of tests, this should be kept in mind.

In redesigning a model during testing, an accurate record of all changes must be made. Of course, only one change must be made at a time. Too often, two or more changes are made at a time and it is impossible to determine the single effect of each change.

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during the testing program. A number of changes will have been made in the test model and each of these, in turn, will introduce other small changes that were not intended. It's easy to overlook some of these small changes and, after a while, it may well turn out that there are five or six factors in this test sample which are not exactly as the designer intended them to be. Any one of these by itself will not have been sufficient to make trouble, but by the time they are all added together, the test sample becomes inoperative and there is no evident reason for this condition. At a time like this, it is well to go back and examine the models critically to be sure that everything is exactly as planned.

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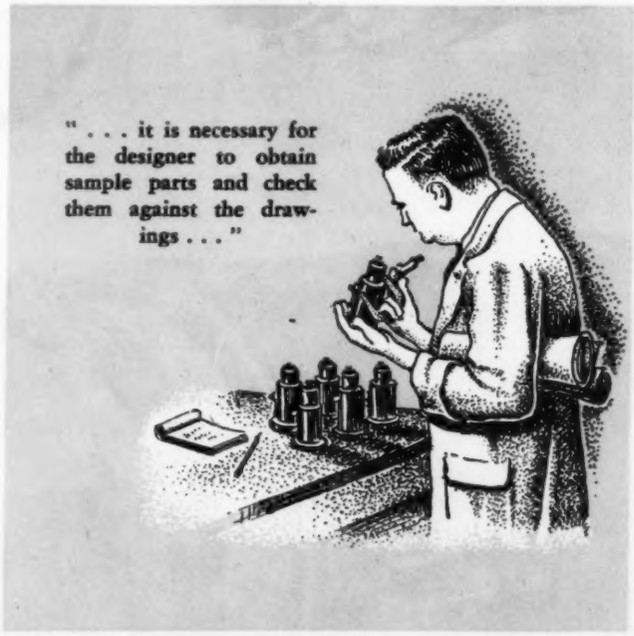

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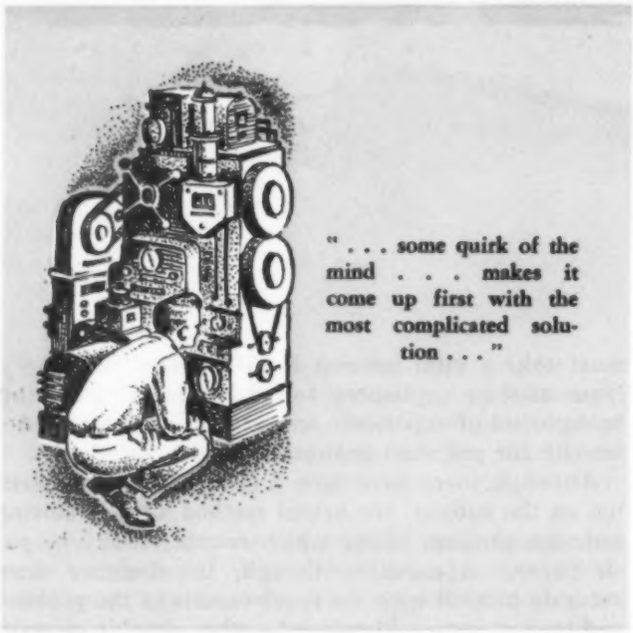

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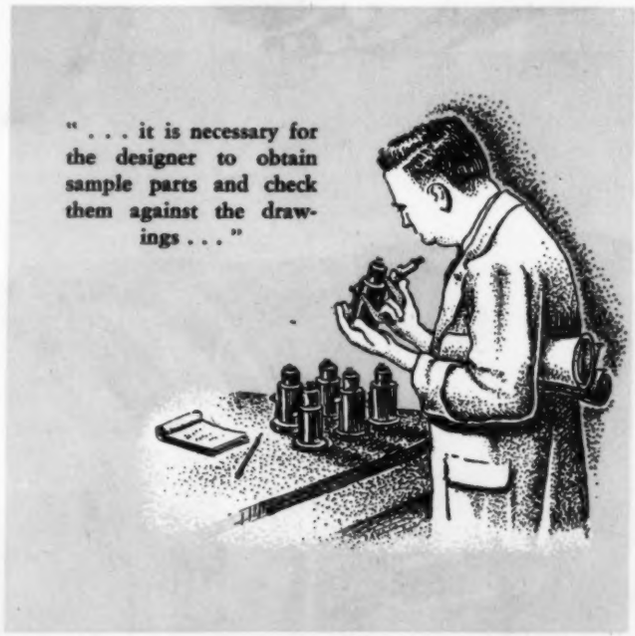
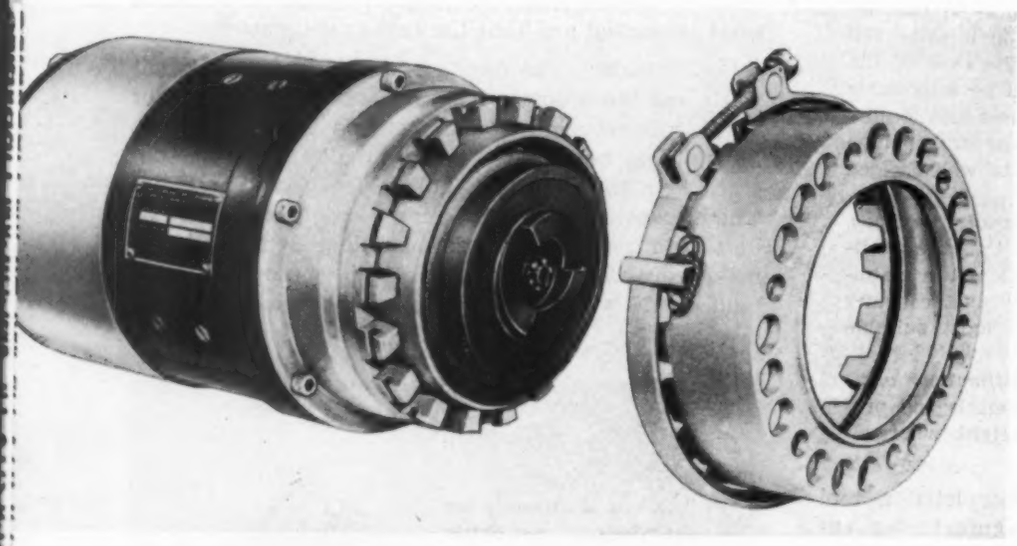
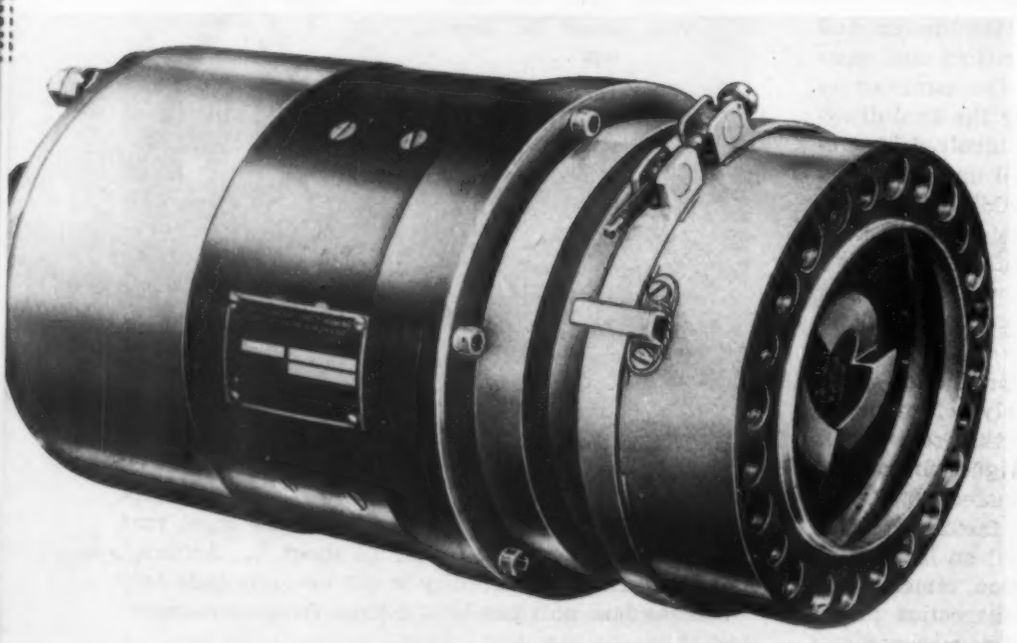


and put into production, it seems for the most part that the designer could forget all about it. Actually, the designer's responsibility is not over—it ends only when the last unit has been retired from active service.

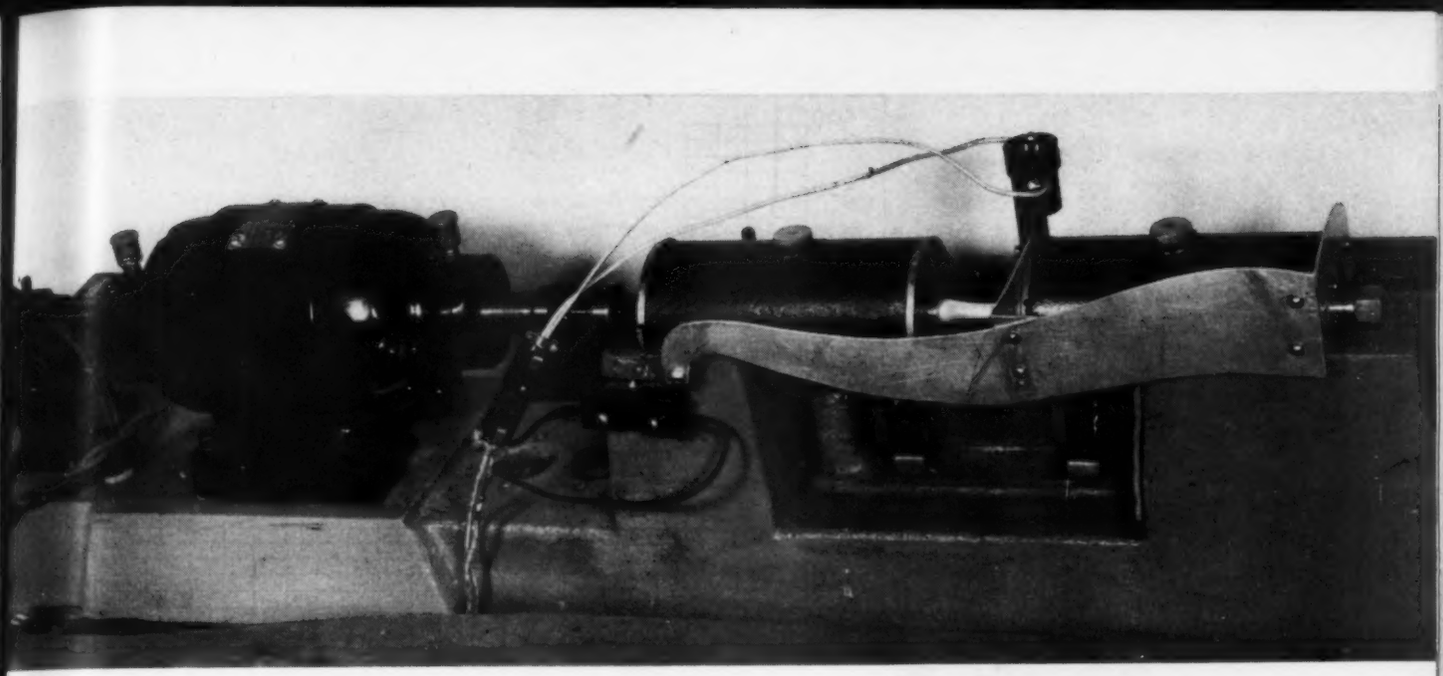
SCANNING the Field For Ideas

Quick-detachable mountings, below, facilitate rapid removal of accessories for inspection, testing, maintenance, and replacement. By turning one bolt on a clamp ring, a unit may be removed or replaced in position. This mount, used on Eclipse - Pioneer jet - engine starters, consists of two crown gears held together with a mechanically loaded retaining ring which fits into grooves cut in the outside diameter of the mating parts. The mounting head is bolted to the engine pad and remains with the engine at all times. It is machined from a high-quality steel forging and heat treated to a Rockwell hardness of 36-40 C. The gear housing is bolted to the starter motor and remains with the starter at all times.





Both mating parts have 18 ground teeth with grooves machined in the teeth at the outside diameter. These grooves are located so that, when the teeth are meshed, the grooves are slightly displaced from each other in the direction which will cause a retaining ring, wedged into the grooves, to pull the teeth tightly into mesh. The retaining ring contacts only the side of each groove nearest the tops of the teeth. On the gear housing, the groove side is straight while on the mounting head it is tapered. The ring has corresponding straight and tapered sides. Usually the retaining bolt is tightened with a torque of 75 to 80 lb-in. With this mounting, the starter illustrated has an overhang moment of approximately 400 lb-in. and a critical frequency in excess of 13,000 cycles per minute with a vibratory double amplitude of 0.0015-inch applied to the mounting pad.



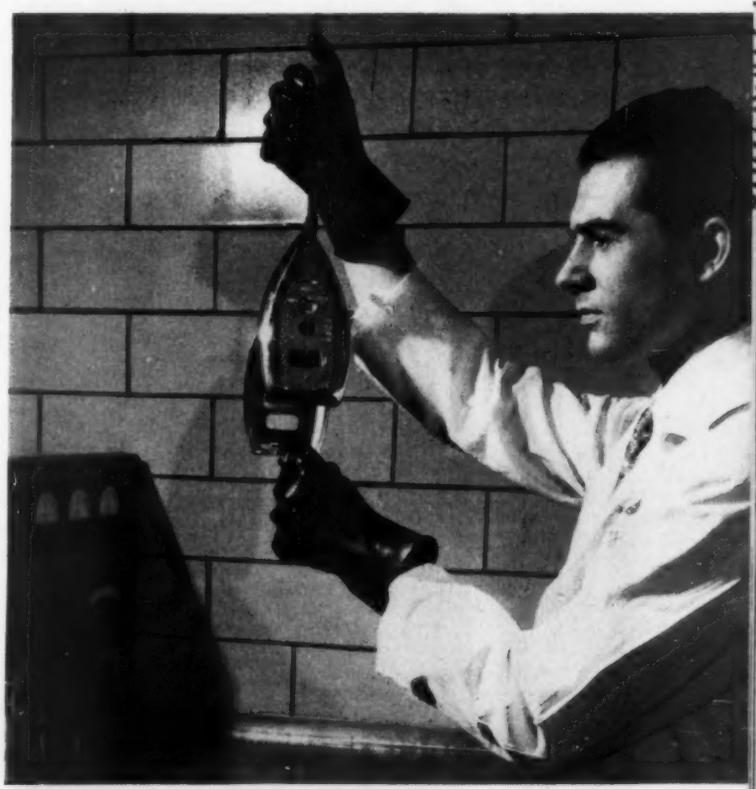
Automatic stopping devices, one vibration sensitive and another deflection responsive, are utilized on the fatigue testing machine, above, to indicate when incipient failure occurs. With careful adjustment, the arrangement is sensitive to cracks having a length as little as 5 to 10 per cent of the circumference of specimens 0.25-inch diameter or larger. Connected in parallel, either device will stop the machine; sometimes one will respond first, sometimes the other depending upon the peculiarities of the particular incipient crack.

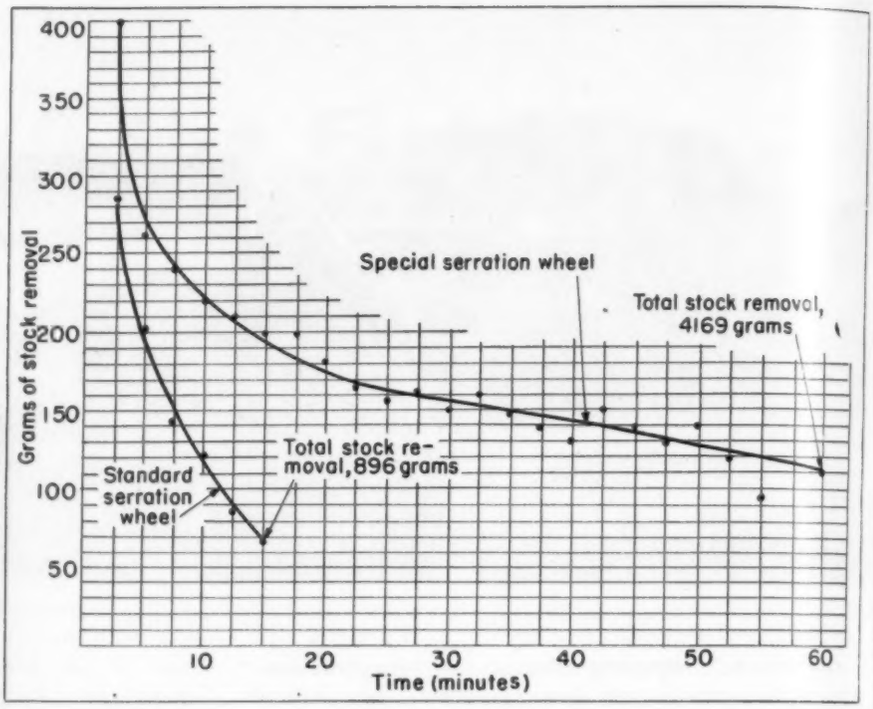
Developed by the National Bureau of Standards, the vibration-sensitive device is fastened rigidly to one of the bearing boxes and utilizes a steel ball poised on a three-pronged pedestal. Vibration shakes the ball from its perch, closing an electrical circuit that shuts off the machine. Sensitivity of the device may be adjusted by varying the distances of the pedestal prongs from each other.

The deflection-responsive unit utilizes a microswitch operated by a lever. This lever is fastened to one of the bearing boxes and, at the other end, carries an adjusting screw which bears on an actuating leaf on the switch. With the machine running, the adjusting screw is advanced until a small change in the position of the lever will trip the switch.

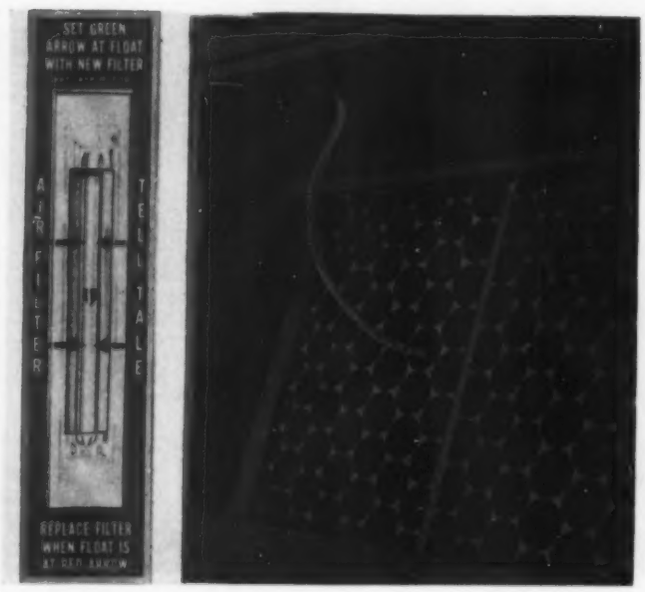
Chromium plating, right, by the revolutionary method of periodic reverse-current plating may conserve critical nickel and still provide bright corrosion-resistant trim for automobiles and appliances. Where no nickel at all is permitted, the process uses chrome-on-copper that is as bright as the standard finish. Its serviceability, however is not as good as a copper-nickel-chrome or a nickel-chrome finish.

In the process, one-thousandth inch of copper is plated onto the steel base. If nickel is allowed, a layer is added one-half the thickness of the copper. The coating is completed with a film of chrome that may be less than 0.00001-inch thick. The key feature of plating system is the periodic short-duration reversals of the plating current. This alternately deposits metal on the surface to be plated and removes some during reversal, building up a plate quality superior to anything previously obtained from direct-current plating. Each time the current is reversed, inferior metal deposits are removed from the surface and succeeding layers are thus plated on sound metal to produce a finish that has superior brightness, strength and freedom from flaws. The process has been employed for more than a year by Westinghouse for electroplating its appliances. Several automobile manufacturers are adopting it for use on accessories.





Serrated rubber contact wheel, above, for use as an idler on belt backstand grinders provides more uniform cutting and doubles the life of abrasive belts in applications where belt glazing is encountered. Shape of the serrations—the relief angle, wide-spaced lands and, narrowness of lands—is based on the design of milling cutters and is responsible for this improved performance. This shape, developed by Carborundum Co. engineers, causes a controlled breakdown in the bond of the abrasive belt so that its tendency to glaze or load-up is reduced greatly. In the set of curves above is shown the comparative performance of the special serration wheel and a standard serration wheel. In each case a 14-foot 4-inch resin industrial cloth belt (60 ALOM) was employed to grind hot-rolled 1020 angle iron at 5600 sfpm. The standard-wheel grinder required replacement after fifteen minutes with a total stock removal of 896 grams whereas the grinder with the special wheel removed 4169 grams in one hour and still was grinding at a high rate.



Air-filter performance is visibly indicated by the gage illustrated at left, telling when the filter needs replacement. The instrument, developed by Dwyer Instrument Co. and applied to warm-air furnaces by the Heil Co., measures the resistance drop across a filter by indicating the difference between up-stream and down-stream pressures. As shown in the right-hand illustration, a flexible plastic tube is inserted through the filter to the down-stream side and is attached to the gage mounted on the outside of the compartment. This gage contains a manometer tube with a float to indicate pressure drop. To compensate for variations in filters, the float is set to a zero reading when the filter is new. Then as the filter becomes less efficient due to collecting dirt, the gage indicates when replacement becomes necessary to retain proper operation. Pressure drop across a new filter varies between 0.08 and 0.12-inch water. When it reaches 0.18, the filter is dirty.

DESIGNING HYDRAULIC DAMPERS

. . . with radial-orifice damping valves

By William E. Soong *Armour Research Foundation, Chicago, Ill.*

DAMPING is associated with energy dissipation. Coulomb damping arises from the sliding of dry surfaces, while moving a body at moderate speeds through a fluid produces viscous damping. These are only two of many types of damping.[1] In some systems, it is desirable to introduce additional damping other than that inherent in the system itself. For example, in servomechanism design additional damping in one form or another is used for stabilization purposes.[2] This additional damping is intended to alter the overall behavior of a system. The shock absorbers used with automobile spring systems constitute another example.

This article concerns only the procedure involved in the design of a damping valve that will produce the desired damping force in a prescribed manner. From the system analysis, the type of damping best suited for the particular system can be determined.

In the design to be discussed, damping is achieved with a linear-motion damping cylinder or a rotary-motion damping cylinder. As the piston is moved in the direction *S* in the linear-motion damping cylinders, *Figs.* 1 and 2, the damping valve is actuated by the resulting pressure, causing a motion in the direction *X*. This displacement of the damping valve varies the orifice area, making it smaller or larger, depending on the design of the damping valve. The other damping valve operates when the piston is moved in the opposite direction. The principle in-

[1] References are tabulated at end of article.

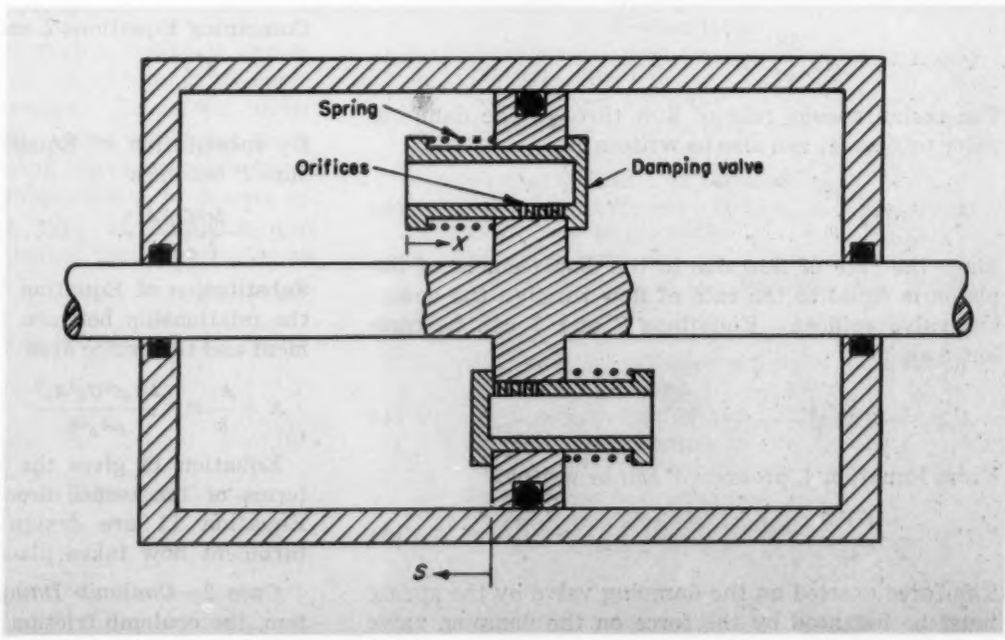


Fig. 1—Linear motion damping cylinder. As piston is moved in direction *S*, damping valve moves in direction *X* against spring force letting oil flow through orifices

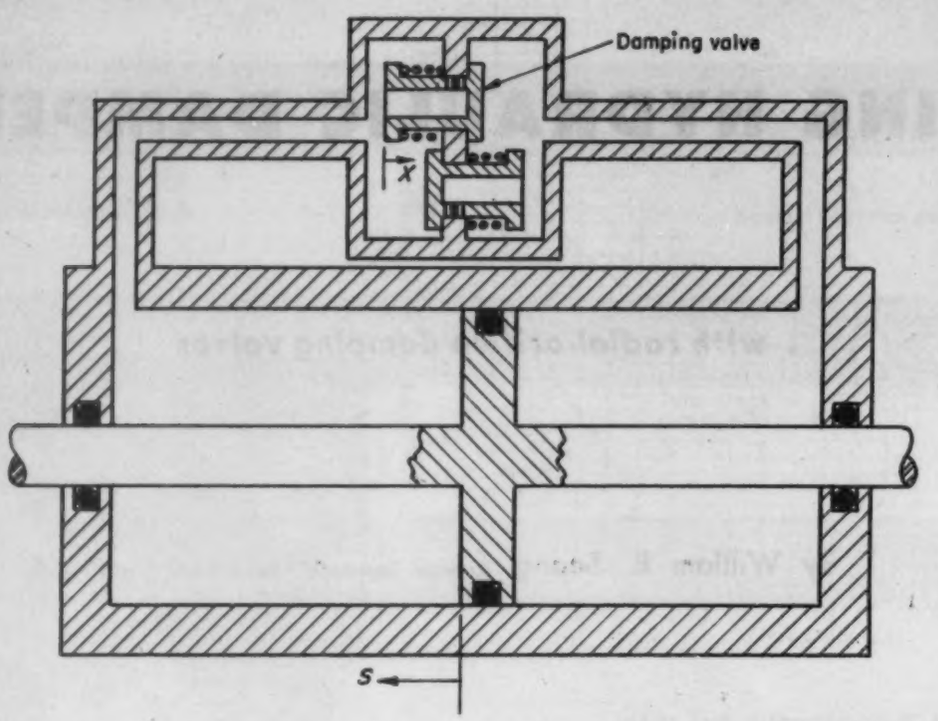


Fig. 2—Left—Linear-motion damping cylinder with damping valves in external lines

Fig. 3 — Right—Rotary-motion damping cylinder

volved in a rotary-motion damping cylinder is the same. However, in some systems a rotary-motion damping cylinder gives a more simple linkage arrangement, while in other systems a linear-motion damping cylinder can be used more advantageously.

THEORETICAL ANALYSIS: The following analysis holds for the designs shown in *Figs.* 1 and 2. The analysis for *Fig.* 3 would be similar in nature.

The derivative of the piston displacement with respect to time gives the velocity of the piston:

$$V_p = \frac{dS}{dt} \quad \ldots\ldots (1)$$

The instantaneous rate of flow is the product of the area and the velocity of the piston. Thus,

$$Q = A_p V_p = A_p \frac{dS}{dt} \quad \ldots\ldots (2)$$

The instantaneous rate of flow through the damping valve orifices A_o can also be written as

$$Q = C_d A_o \sqrt{\frac{2P}{\rho}} \quad \ldots\ldots (3)$$

Since the rate of flow due to the displacement of the piston is equal to the rate of flow through the damping valve orifices. Equations 2 and 3 can be combined as

$$A_p V_p = C_d A_o \sqrt{\frac{2P}{\rho}} \quad \ldots\ldots (4)$$

From Equation 4, pressure P can be written

$$P = \frac{\rho A_p^2 V_p^2}{2 C_d^2 A_o^2} \quad \ldots\ldots (5)$$

The force exerted on the damping valve by the spring must be balanced by the force on the damping valve due to the resulting hydraulic pressure. Therefore, for the damping valve,

$$A_v P = kX \quad \ldots\ldots (6)$$

Case 1—*Viscous Damping:* For viscous damping, the damping force is, by definition, proportional to the velocity of the piston. It is the purpose of this design to provide the necessary orifice area so that

$$F_d = cV_p \quad \ldots\ldots (7)$$

The damping force on the piston rod can also be written as

$$F_d = A_p P \quad \ldots\ldots (8)$$

Combining Equations 7 and 8

$$V_p = \frac{A_p P}{c} \quad \ldots\ldots (9)$$

By substitution of Equation 9 into Equation 5 pressure P becomes

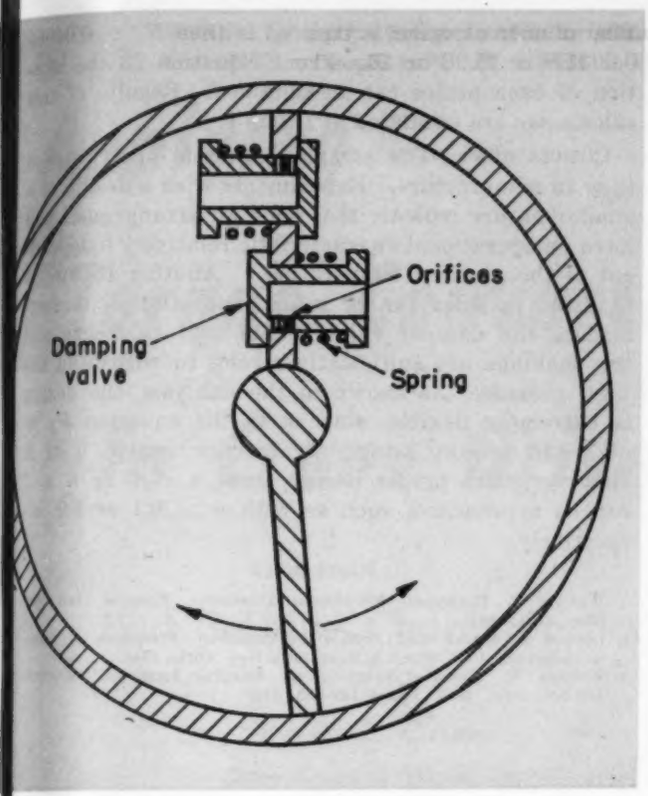
$$P = \frac{2c^2 C_d^2 A_o^2}{\rho A_p^4} \quad \ldots\ldots (10)$$

Substitution of Equation 10 into Equation 6 produces the relationship between the damping valve displacement and the orifice area.

$$X = \frac{A_v}{k} P = \frac{2 A_v c^2 C_d^2 A_o^2}{\rho A_p^4 k} \quad \ldots\ldots (11)$$

Equation 11 gives the instantaneous value of X in terms of the orifice area, since all other factors in Equation 11 are design constants. This assumes turbulent flow takes place through the orifices.

Case 2—*Coulomb Damping:* In a mechanical system, the coulomb friction force is nearly constant and



depends on the nature of the sliding surfaces and the normal pressure between them as expressed by the equation of kinetic friction. In this design, the damping valve must provide the necessary orifice area so that

$$F_d = \mu N = a \quad \ldots\ldots (12)$$

By substitution of Equation 12 into Equation 8, the damping force is

$$F_d = A_p P = a \quad \ldots\ldots (13)$$

From Equation 13, the pressure is

$$P = \frac{a}{A_p} \quad \ldots\ldots (14)$$

Equation 14 indicates that such a design is impossible. Since a and A_p are design constants, P is required to be a constant pressure. Therefore, under such a condition, the damping valve would not move and the orifice on the damping valve becomes fixed.

Case 3—Damping Force Proportional to Square of Piston Velocity: For this type of damping, the damping force can be represented mathematically as

$$F_d = cV_p^2 \quad \ldots\ldots (15)$$

From Equations 15 and 8, the velocity of the piston can be written as

$$V_p = \sqrt{\frac{A_p P}{c}} \quad \ldots\ldots (16)$$

Substitution of Equation 16 into Equation 5 gives

$$P = \frac{\rho A_p^2}{2C_d^2 A_o^2}\left(\frac{A_p P}{c}\right) \quad \ldots\ldots (17)$$

Simplifying Equation 17

$$A_o = \sqrt{\frac{\rho A_p^3}{2C_d^2 c}} \quad \ldots\ldots (18)$$

Equation 18 indicates that the orifice area does not vary since all the factors on the right-hand side are design constants. Therefore, a fixed orifice is required.

Case 4—Damping Force Proportional to Cube of Piston Velocity: For this type of damping, the damping force can be written as

$$F_d = cV_p^3 \quad \ldots\ldots (19)$$

From Equation 19 and Equation 8 the velocity of the piston can be written as

$$V_p = \sqrt[3]{\frac{A_p P}{c}} \quad \ldots\ldots (20)$$

Substitution of Equation 21 into Equation 6 gives

$$P = \frac{\rho^3 A_p^8}{8c^2 C_d^6 A_o^6} \quad \ldots\ldots (21)$$

$$X = \frac{A_v}{k} P = \frac{A_v \rho^3 A_p^8}{8kc^2 C_d^6 A_o^6} \quad \ldots\ldots (22)$$

Equation 22 shows the instantaneous relationship between the damping valve displacement and the orifice area.

EXAMPLE: Since viscous damping is desirable in many mechanical systems, a sample calculation is carried out to further clarify the design procedure.

Assume the following specific values: $A_p = 6$ sq in., $A_v = 0.2$ sq in., $c = 60$ lb per in. per sec, $C_d = 0.77$, $k = 54$ lb per in., $\rho = 0.000081$ lb sec^2 per in.^{4} and velocity of the piston ranges from 0 to 10 ft per sec.

From Equation 9 the maximum pressure can be calculated as: $P_{max} = cV_p/A_p = 60(10)/6 = 100$ psi. From Equation 6 the maximum damping valve displacement is $X_{max} = A_v P/k = 0.2(100)/54 = 0.370$

Nomenclature

a	= Constant force, lb
A_i	= Area of each individual orifice, sq in.
A_o	= Instantaneous orifice area, sq in.
A_p	= Area of the piston, sq in.
A_v	= Area of the damping valve, sq in.
c	= Damping coefficient
C_d	= Coefficient of discharge
F_d	= Damping force, lb
k	= Spring constant of the damping valve spring
N	= Normal force, lb
N_o	= Number of individual orifices
P	= Instantaneous pressure of fluid in the cylinder, psi
Q	= Instantaneous rate of flow, cu in. per sec
S	= Displacement of piston, in.
V_p	= Velocity of piston, in. per sec
X	= Damping valve displacement, in.
μ	= Dynamic coefficient of friction
ρ	= Mass density of the fluid, lb-sec^2 per in.^{4}

Table 1—Orifice Area vs Valve Displacement

No.	A_o	X	No.	A_o	X
1	0.0032	0.0015	9	0.0288	0.1249
2	0.0064	0.0062	10	0.0320	0.1542
3	0.0096	0.0139	11	0.0352	0.1866
4	0.0128	0.0247	12	0.0384	0.2221
5	0.0160	0.0386	13	0.0416	0.2606
6	0.0192	0.0555	14	0.0448	0.3023
7	0.0224	0.0756	15	0.0480	0.3470
8	0.0256	0.0987			

in. With the assumed values, Equation 11 can be simplified to

$$X = \frac{(2)(0.2)(60)^2(0.77)^2}{(0.000081)(6)^4(54)} A_o^2 = 150.6A_o^2 \quad \ldots\ldots\ldots\ldots (23)$$

Maximum orifice area can be found by substituting X_{max} into Equation 23: $A_o = \sqrt{0.370/150.6} = 0.0496$ sq in. By using a No. 52 drill, each individual orifice area becomes $A_i = \pi(0.0635)^2/4 = 0.00317$ sq in. The number of orifices required is then $N_o = 0.0496/0.00317 = 15.66$ or 16. From Equation 23 the location of each orifice can be obtained. Results of this calculation are tabulated in TABLE 1.

CONCLUSION: The sample design is practical and easy to manufacture. Experiments with a design of a similar nature indicate that such an arrangement will have an operational characteristic relatively independent of the ambient temperature.[3] Another feature is that the cylinder can be made small and yet accommodate the damper valve if the wall thickness and the packings are sufficiently strong to withstand the high pressure. As shown in the analysis, the design is extremely flexible, since n in the equation $F_d = cV_p^n$ can be any integer or fraction except 0 or 2. However, with proper design, even $n = 0$ or $n = 2$ can be approached, such as with $n = 0.1$ or 1.9, respectively.

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Testing Temperature-Sensing Devices

EFFICIENT operation and adequate protection of the power plant in jet engines requires rapid reduction in the temperature of the gas stream whenever this temperature exceeds a limiting safe value. The rates of response of whatever temperature-sensing devices are used thus assume considerable importance in jet-engine operation. Various methods for determining response rates have been worked out, but in most cases they have proved unsatisfactory because they failed to simulate operating conditions adequately.

A. I. Dahl and E. F. Fiock of the National Bureau of Standards have developed apparatus which determines the rate of response of jet-engine temperature elements under conditions approximating those obtaining in the combustion stream. With this equipment, response times as short as 0.02 second have been measured for a wide variety of thermocouples, resistance thermometers, and thermistors.

This apparatus consists essentially of a jet-engine combustor, or burner, with provision for mounting instruments in the exhaust gas stream, and a device for producing rapid changes in the temperature of the mounted test instrument. A compressor or blower supplies air to a single Jumo 004 turbo-jet engine combustor equipped with its normal fuel injector and spark plug. Exhaust gases from the combustor pass through two 90-degree turns, through a perforated plate, and then through about 10 feet of straight pipe before reaching the test section, which has three hatches for mounting instruments. In this way, the gas stream is kept at essentially uniform temperature and velocity over the central half diameter of the test section, and exposure of any instrument to direct radiation from the flame is prevented by the turns in the duct system.

Gas temperature and flow rate at the combustor outlet are controlled by a valve at the inlet to the compressor and by adjusting the fuel pressure. A bleed line containing a butterfly valve also provides an auxiliary control of the flow in the test section, independent of the operating conditions of the burner. Pressures observed with a pitot-static tube, together with the known value of gas temperature, permit calculation of the mass flow rate in the test section.

For measuring rate of response, the temperature of the gas surrounding the test instrument must be changed suddenly. This cannot be accomplished with sufficient rapidity by controlling the combustor. Apparatus was therefore developed for quickly immersing the instrument without altering the steady flow of exhaust gas in the test section. In this device, an Inconel tube, projecting vertically upward through the test section and held in position around the test instrument by a release plate, provides a flow channel for cold air. When the release plate is pulled out of the way, a spring suddenly removes the tube, exposing the instrument to the hot gas of the main stream almost instantaneously. During the downward movement of the tube, the supply of cold air is stopped automatically. In this way a test instrument at a known, moderate temperature (controlled by the air rate through the Inconel tube) can be brought in contact with exhaust gas at any given temperature and at any mass flow rate within the capacity of the system.

Applying Torque Converters To Crane Drives

Part 3–Drive Characteristics

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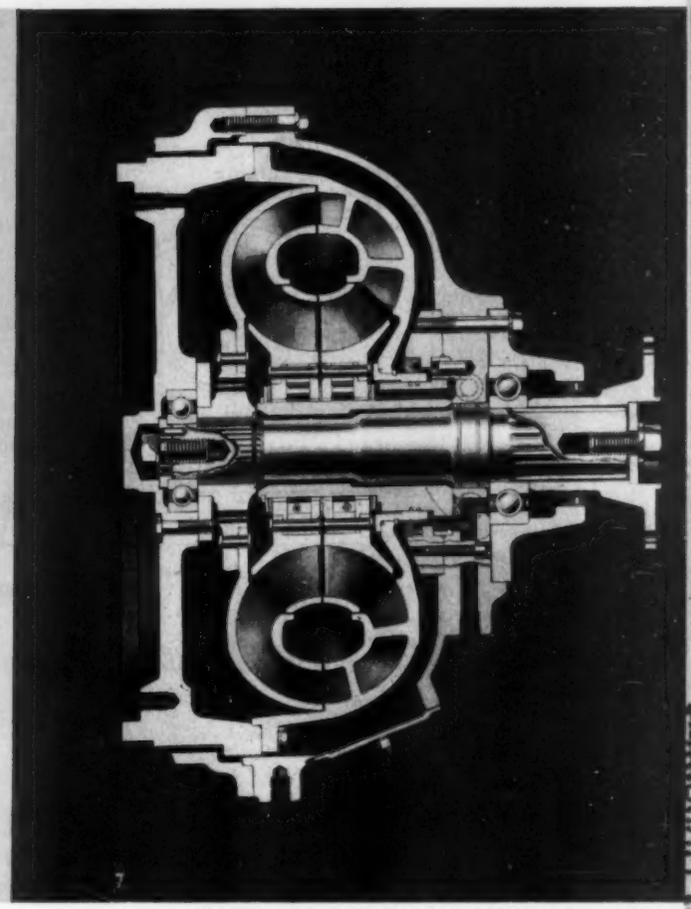

Illustration, courtesy Detroit Diesel Engine Div., G.M.C.

Fig. 20—Above—A typical three-phase converter designed for mounting on the flywheel and housing of a diesel engine. Arrangement of components is shown in *Fig.* 23

Fig. 21—Below—Full revolving rail crane typical of those incorporating fluid torque converters

FOR a modest investment, a fluid torque converter, *Fig.* 20, may be applied to heavy machinery with a highly profitable yield in improved control and reduced maintenance. In this series of three articles, design problems associated with the application of torque converters are discussed, using full revolving rail cranes, such as illustrated in *Fig.* 21, to analyze operating characteristics. It is the purpose of this article to apply the idealized concepts of Part 2 to actual units, discussing the essential features of converter construction and auxiliary equipment, particularly the tailshaft governor.

Part 2 presented an idealized analysis of the hydraulic action in couplings and converters. How does the design of practical units affect this analysis? The need for feeding the fluid discharged from turbine or stator vanes back into the impeller causes departures in actual construction from that indicated by the theoretical analysis. *Fig.* 22 shows diagrammatically a half section of a typical coupling. Fluid flow, instead of being entirely axial in direction as in the idealized concept, is just as much radial. It is not necessary that the vanes be curved; in fact in the usual coupling design they are flat, often so that either vane set may be used as the turbine or impeller. The radius at C being smaller than that at D, the passage at C is usually wider radially so that the area is substantially constant throughout the fluid flow path.

The energy transferral in the coupling design of *Fig.* 22 is secured from the change in tangential velocity. The ve-

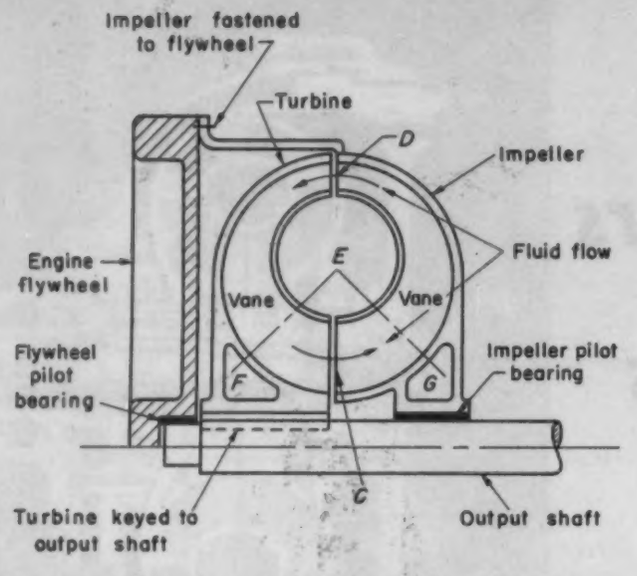

Fig. 22—Diagrammatic section of a fluid coupling

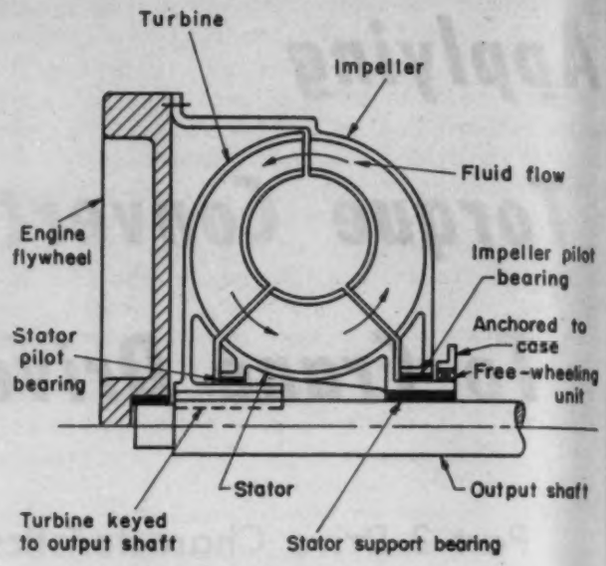

Fig. 23—Diagrammatic section of a fluid converter

locity normal to the axis at *D* will be to that at *C* in proportion to the radial distances. Commonly this will be in the order of two to one, so that the energy of a unit "slug" of fluid at *D* may be four times that at *C*, the difference being the input energy. The reverse occurs in the turbine. Although this action is different from that portrayed by *Figs.* 14 and 15, actually it is as if the vanes were curved and arranged as in the earlier figures. The validity of the conclusions is not substantially affected by the actual construction.

Flat radial vanes give excellent entrance conditions when the turbine is running near impeller speed, entrance into both wheels being substantially tangential to the vanes. Since, as previously discussed, the coupling operates with a low order of slip at rated loads, efficiency under normal operating conditions is excellent. Favorable entrance exists also when the turbine is over-running the impeller, so that excellent engine braking may be obtained from a coupling.

Has High Energy Absorption at Stall

At speeds differing widely from synchronous, however, entrance conditions are poor and losses are high. At stall, for example, the tangential velocity as the fluid flows from impeller to turbine must be completely removed by an abrupt change in direction of flow, similarly at entrance into the impeller. This, coupled with the relatively simple flow path, giving a high circulating flow rate, results in a high energy absorption capacity at stall.

If the turbine vanes in *Fig.* 22 were stopped at line *E-F*, and the impeller did not start until line *E-G*, the vane portions between these two lines could be made into a stator by anchoring them. This is shown diagrammatically in *Fig.* 23. The unit shown is two-phased, the stator being arranged to free-wheel when the turbine enters the coupling range.

Again, the actual design differs from the presentation in the preceding article. The fluid follows a path which has as much radial flow as axial, to secure recirculation. In the converter, though, the vanes are curved and, while something of the same action occurs as in the coupling, essentially the velocity changes are due to the curvature of the vanes. In any event, the general conclusions still hold.

As with the coupling, it may be considered that the fluid flow consists of two motions—a tangential component, the change in value of which develops the torque reactions, and a circulatory motion. The latter affects the flow rate. Changes in the circulatory rate will change torque values. All changes will be proportionate so that relative values are dependent on the tangential change in velocity.

In *Fig.* 20 is shown a single-stage three-phase converter arranged for diesel-engine flywheel mounting, the unit actually used in this application. The elements have the same relative positions as in *Fig.* 23, the fluid circulating counter-clockwise in the upper half of the illustration. As the fluid passes through the impeller vanes, energy is added. As it passes through the turbine, the same energy that was added to the fluid is removed. As it passes through the stator vanes, no change in energy occurs but the direction of flow (tangentially) is altered to permit more favorable entrance into the impeller vanes and thus develop a torque on the turbine vanes which is different from that introduced by the impeller. Any other energy changes are losses due to inefficiency of fluid flow.

Certain auxiliary equipment is necessary to a satisfactory operating unit. Cavitation due to air becoming entrapped in the fluid has always been a prob-

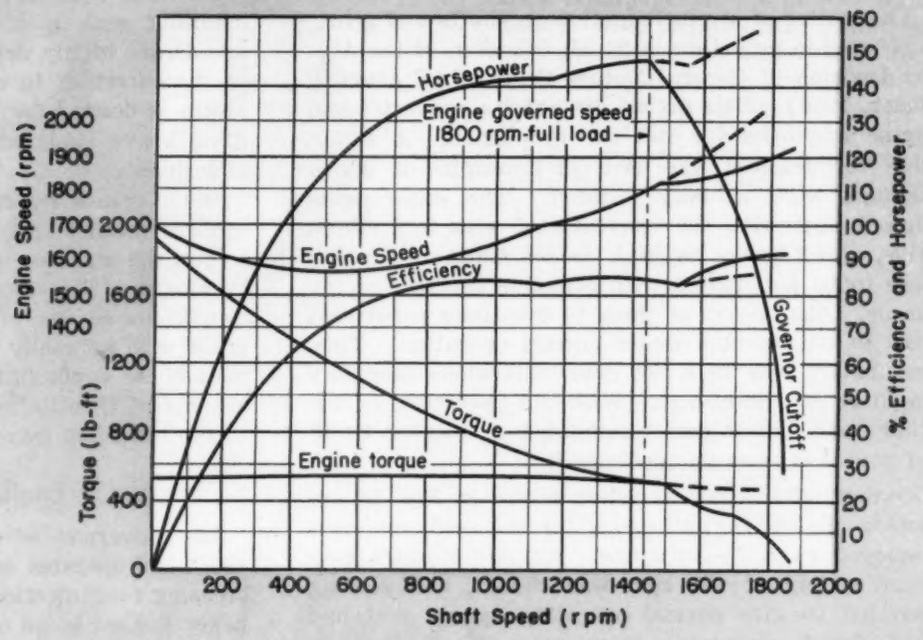

Fig. 24—Output shaft torque and power, efficiency, engine torque and speed plotted against output shaft speed for full throttle

lem. Cavitation also develops because of vaporization of the oil from over-heating. In order to reduce these two effects, this converter is completely full and maintained under a static head of 75 psi or more by means of a charging pump.

Converters are frequently operated at stall or near stall speeds, generating heat in the oil. Current practice utilizes a charging pump with controlled leakage to provide circulation through the unit and through external pipes to an oil cooler.

What are the advantages and disdavantages to be expected from the application of a fluid torque converter to a locomotive crane? The following gains may be expected:

1. A fluid drive reduces the transmission of torsional vibrations and shock from the engine
2. Being completely automatic, a converter, eliminates the need for operator attention
3. The usual engine disconnect clutch may be omitted
4. The converter permits quick application of the clutches reducing the maintenance needs of these elements
5. On switching and hoisting operations the converter makes possible placing the "shoulder against the load" as with steam power
6. Shock loading on the gears and shafts is reduced
7. A converter with sufficient torque ratio range eliminates the need for a gear-shift transmission.

The following disadvantages may be anticipated:

1. The unit increases initial cost
2. Heat disposal equipment may be inadequate
3. Lower efficiency is expected, compared with conventional drives
4. A geared unit maintains reasonably constant speeds, but the converter is a floating unit.

In a conventional drive it is necessary to slip the clutches until a crane motion is brought to speed. Even with the usual three-speed transmission this must be repeated at each step. But with the fluid drive the entire accelerating burden is placed upon the converter, the clutches serving merely for disconnect purposes.

By throttling the engine, the output shaft may be connected to the wheels with the crane stationary. Opening the throttle increases the fluid pressure against the turbine vanes until sufficient pressure is reached to cause the crane and its load to move.

After the load has been raised, simply notching the throttle back reduces torque until the load is bal-

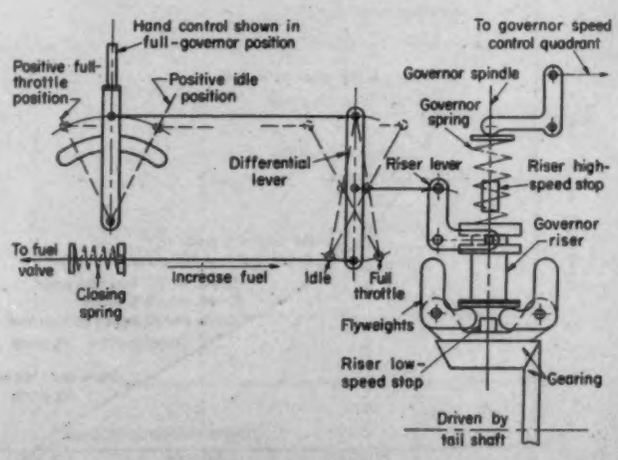

Fig. 25—Schematic representation of tail-shaft governor and manual fuel control

anced. Further reduction of throttle permits the load to overhaul, and it may be dropped at any desired rate.

The matter of stress reduction on shafts and gears is covered in an article by R. M. Schaefer, of the Allison Division of General Motors Corp. (*SAE Journal*, March, 1951). This article discusses a converter and engine employed for rail car propulsion. A strain gage torquemeter was used to determine if shock loadings were actually reduced. The experiments showed that with the conventional gear and clutch drive, shock peaks as high as ten times rated load were to be anticipated with complete reversal of the torque. Also, peaks of three to five times rated load were to be expected under normal operation. This, presumably, was for a new gear train where gear play would be at a minimum. With the converter, on the other hand, shock peaks amounted to only 10 to 15 per cent and were damped rapidly.

Output shaft characteristics shown in *Fig.* 24 are plotted against output speed, for the converter unit employed on a 25-ton crane. An output-shaft governor setting of 600 rpm was chosen, and gearing provided to give normal operating speeds that had been found acceptable from conventional designs. Torque at this speed is 1100 lb-ft, which gives acceptable hoist line pulls, etc. Stalled torque is 1900 lb-ft, which gives a tractive effort of the crane approaching wheel slip, the maximum that can be employed. Top travel speed is somewhat better than *engine* governor cutoff point, or better than twelve miles per hour. Thus, sufficient torque and speed range are available without supplementary means.

At the governed speed of 600 rpm the efficiency is only 76 per cent which appears to be a considerable price to pay for the converter. However, this curve is for *full* throttle, as are most converter data curves. At part throttle this improves to 86 per cent and even better as coupling range is approached. Other factors enter into the fuel consumption too, and further discussion of this point is given later.

On work such as scrap handling with a magnet or handling with a clamshell bucket, maintained line speeds are highly desirable, and varying speeds could be disconcerting to efficient operation. Just the opposite is desired for the travel operation and in handling heavy loads where "full push with zero speed" is desired.

While cranes are designed for definite hoist-line and other operating speeds, almost every operator wishes to run the machine at a different speed, either faster or slower. This is not altogether operator's whim. Conditions on every job are different, so that a governor with an easily variable setting is desirable. To meet these conflicting requirements, a combined governor and throttle control was developed to operate in the following manner:

Engine Speed Floats

The governor is driven by the converter output shaft and operates on the diesel engine fuel rack, increasing fuel injection if the output shaft speed drops below the set speed or closing it if it rises above that speed. This provides for a maintained line speed, the speed of the engine "floating" rather than that of the line. At idle the engine runs at substantially the governor set speed. With a small load demand the engine speed increases until the engine output torque times converter torque multiplication balances the load demand. This is illustrated by the curve of *Fig.* 4 in the first article where engine speed is plotted against torque output.

Inasmuch as a locomotive crane often operates under light loads or stands waiting for service, this arrangement means that the engine, instead of racing at a high idle speed of 1600 rpm or more, actually eases along at 600 rpm waiting for its next load de-

(*Continued on Page* 199)

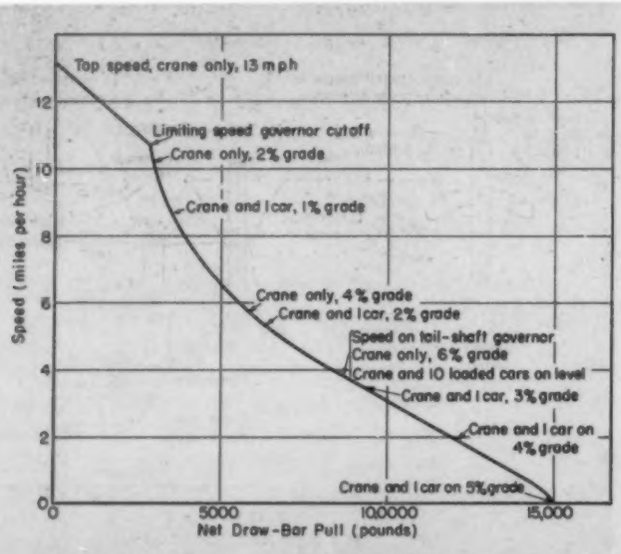

Fig. 26—Speed vs. draw-bar pull for a 25-ton locomotive crane

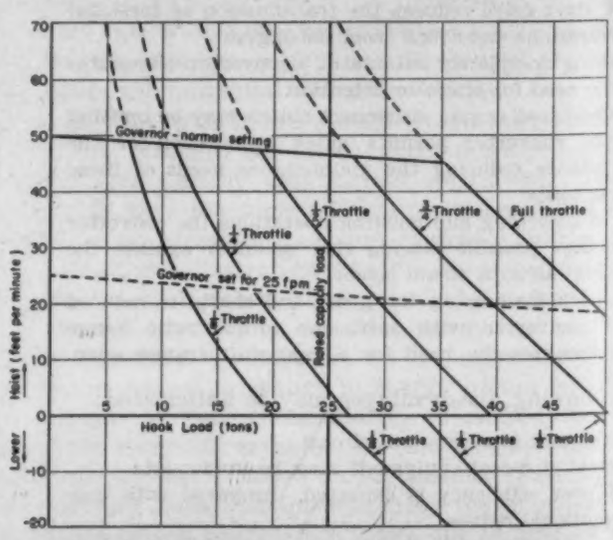

Fig. 27—Load on crane hook vs. hook speed for partial throttle on a 25-ton crane with a 4-part block

Fig. 1—The ability to mold gears of this type has long been one of the primary advantages of the powder metal process. With improvement in tool design, fabricators can now mold cluster gears of equal density throughout all sections. This gear is used in the train of a water meter at a cost saving of approximately 67 per cent as compared to the former cast and assembled gear

Powder Metal Gears

. . . offer economy plus new design opportunities

By Carl G. Levin
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FOR the manufacture of gears, powder metallurgy is still a relatively new process. As such, it has those who view its growth with alarm along with those more enthusiastic proponents who envisage a revolution in gear manufacture.

The facts present their own story. Results to date show that powder metal gears can produce cost savings of 67 per cent and even more in many specific instances, and that these savings are achieved without sacrifice of other important gear qualities, *Figs.* 1 and 2. Powder metal gears rate high in strength, precision, durability and overall performance.

Important, too, are the design opportunities offered in the

Fig. 2—One of the largest gears so far produced by the powder metal process is this 3-inch miter gear for an office machine. Production of this gear as one unit resulted in a cost saving of some 67 per cent. At the same time concentricity tolerances of 0.004-inch TIR and a diameter tolerance of ±0.003-inch were maintained

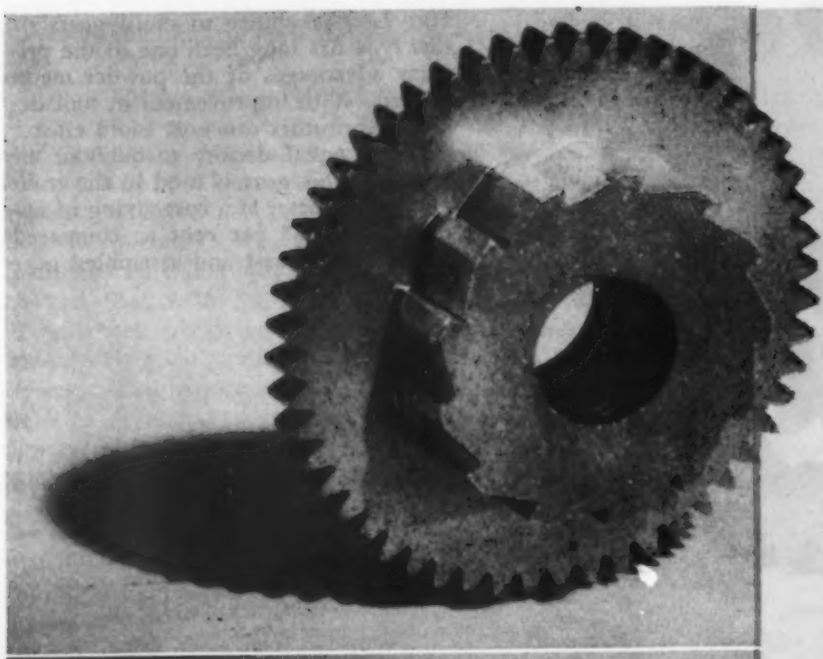


Fig. 3—This ratchet gear, used in dial telephones, formerly required three separate machine setups. The powder metal process eliminated all machining. Concentricity tolerances of 0.002-inch TIR were maintained and parts produced exhibited a fine tooth profile when examined under a comparator at 50 magnifications. Tests showed no sacrifice in strength. Cost savings on this gear are 40 per cent

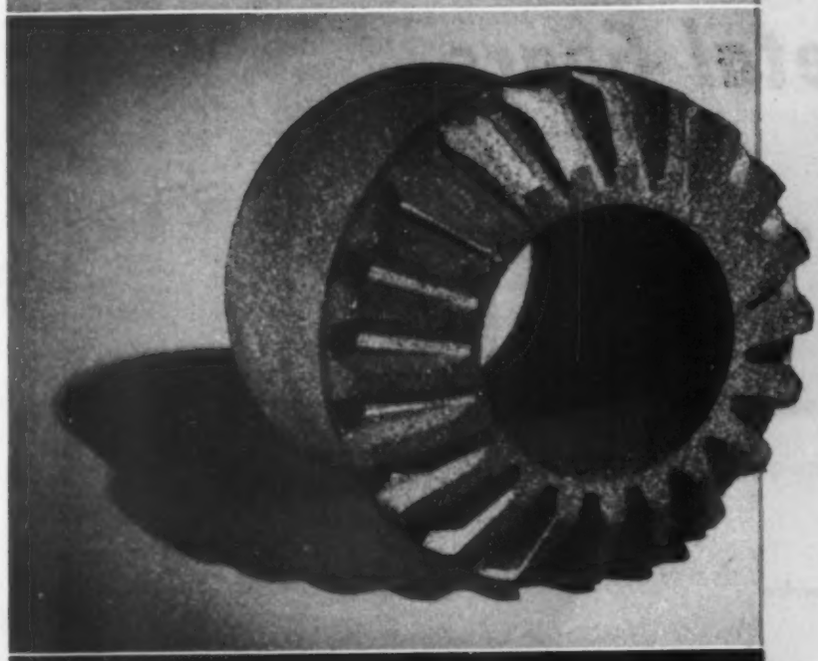


Fig. 4—This gear was produced for a power drill from an impregnated alloy with a tensile strength of 100,000 psi and an elongation of 12 per cent. Tests have shown this gear to outwear the conventional cut gear it replaced. Cost savings are about 67 per cent

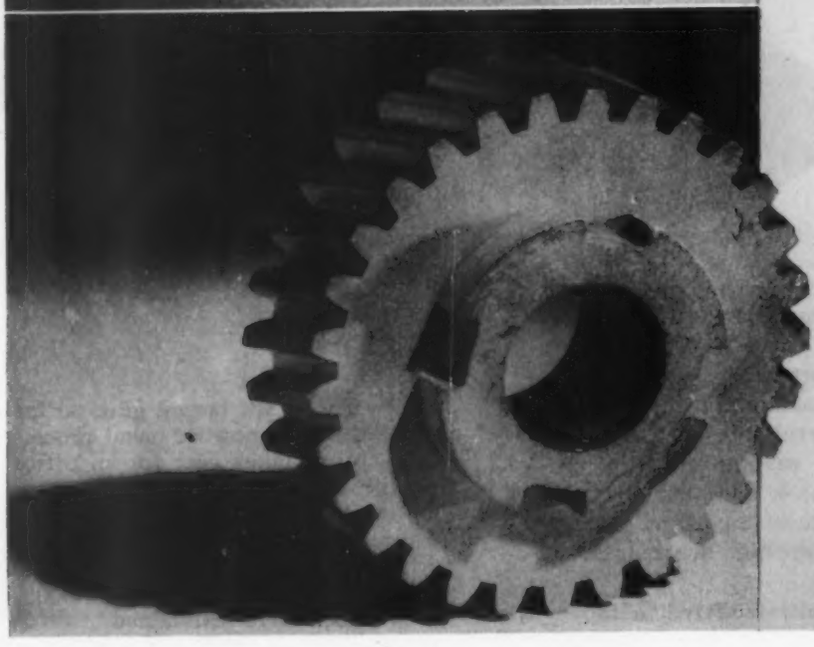


Fig. 5—Another recent accomplishment in the powder metal field is this helical gear, used in a food mixer. Elimination of a throat radius was the design change that permitted powder metal fabrication and helped to achieve a 35 per cent saving with no sacrifice of gear strength

use of powder metals. Irregular shapes for special purposes are easily produced and many gears not adapted to conventional gear cutting methods can be molded as single pieces, *Fig.* 3. In addition to these design advantages, many metals are available in powdered form which are difficult to obtain as bar stock. And because of the mechanical alloying possible with powder metal, special material properties can be achieved that are impossible by any other method.

The gears shown in this article can be made from ferrous or nonferrous alloys. Tensile strengths range upward from 25,000 psi. An interesting technique, recently developed, produces powder metal parts with physical properties approaching those of mild steel. These parts can be heat treated to produce tensile strengths as high as 150,000 psi.

One of the most immediately apparent advantages in the use of powder metal for gear manufacture is self-lubrication. The usually difficult problems encountered in getting oil to every small working surface can be automatically solved because each powder metal part acts as its own oil reservoir, except in the case of nonporous, high-strength alloys. Adequate lubrication and maximum wear resistance are thus assured for the entire life of the gear. This improved wear resistance has enabled gears made from powder metal to set service records of as much as four times the normal expected life, *Fig.* 4.

There are some processing limitations in the use of powder metal. Chief among these are thin or complex curved sections which create complicated handling problems and make the powder metal process impractical. Beyond these limitations, the new design possibilities with powder metal are virtually unlimited except by press capacity.

Decreased tool costs also contribute to economy. Depending on size and shape, one die will often produce as many as 100,000 parts before die wear exceeds tolerance limitations. Complex gear shapes often require a costly sequence of machine and assembly operations when produced by conventional methods, *Fig.* 5. With powder metal these operations are eliminated.

While this article deals only with gears the factors discussed also contribute to the successful use of powder metal in filters, cams, ratchets, wheels, keys, latches, pawls, sprockets and a wide variety of other parts. Applications are equally varied. They include automotive, radio, business, household appliance, electronic, and numerous other machines.

Electronic Manometer Measures Minute Pressures

UTILIZING an electronic pick-up, a diaphragm-type micromanometer, developed recently at the National Bureau of Standards, measures differential pressures in the micron region. Constructed for use with a mass spectrometer, the micromanometer gives direct readings of pressure on a scale that can be calibrated in units of pressure. It is relatively insensitive to temperature changes, will operate in any position, and permits measurements that are totally independent of the type of gas or vapor being measured.

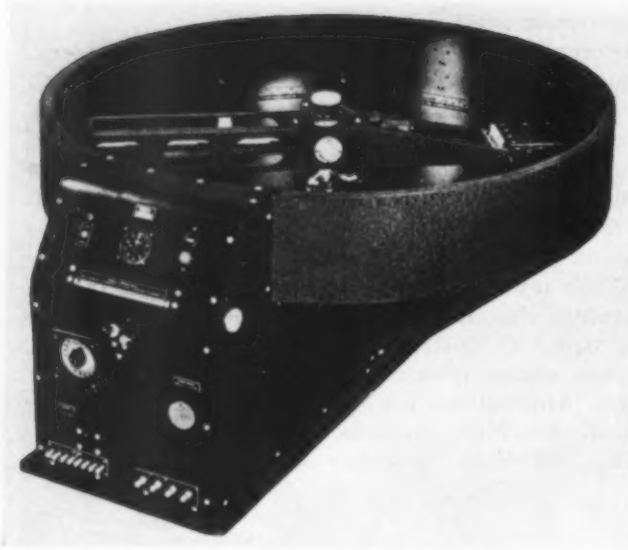
Need for such an instrument arises from the inevitability of error in the usual method of measuring gases for use in a mass spectrometer. A small sample is measured in an ordinary U-tube manometer and passed into the reservoirs of the machine, where it expands to 1000 times its original volume. Its pressure is then assumed to be one one-thousandth of its original pressure, but this assumption fails to account for losses that occur.

It is desirable, therefore, to measure the pressure of the sample in the reservoirs after the losses have occurred. Manometers for the range from one thousandth of a millimeter to one tenth of a millimeter of mercury are usually liquid-level devices, such as McLeod gages, or depend on thermal effects, such as Pirani or thermocouple gages. McLeod gages are accurate, but the presence of mercury or oil vapor introduces difficulties into vacuum work; besides, these instruments are bulky and inconvenient to use. Pirani and thermocouple gages, while avoiding these difficulties, are inaccurate, and, unless special care is used, give only a rough indication of vacuum.

This instrument consists of a pressure cell and an electronic micrometer, enclosed in a glass dome which can be evacuated or filled to any desired reference pressure. The pressure cell, the heart of the instrument, is composed of a thin corrugated diaphragm sealed at the periphery to a slightly dished brass disk. This cell is connected to the gas sample so that change in pressure of the gas causes movement of the flexible diaphragm. Movement of the diaphragm in response to pressure variations is measured by a mutual-inductance micrometer placed over, but not in contact with, the diaphragm.

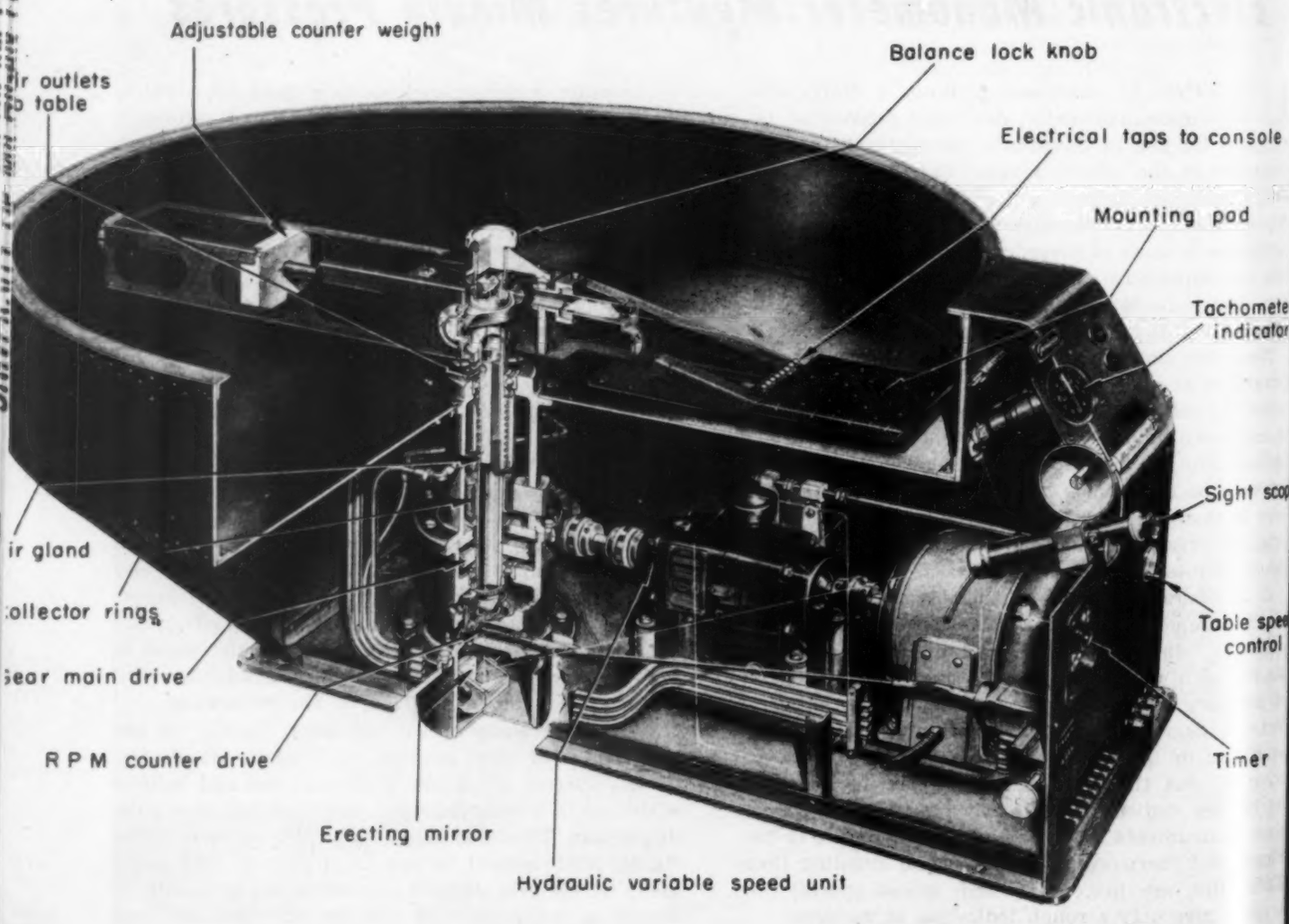
The micrometer was previously developed at the Bureau in connection with the design of indicating devices to measure clearances in journal bearings. In principle, it makes use of the variation in mutual inductance between two concentric air-core coils which results when the distance of the coils from a nonmagnetic metal surface changes. When the metal is brought immediately adjacent to the end of the form supporting the coils, the mutual inductance is reduced to a minimum by what is effectively a "shielding" action of the metal. As the metal is moved away from the coils, the mutual inductance increases as a linear function of the separation.

In the micromanometer, the metal "shield" is the diaphragm of the pressure cell itself. Radio-frequency current is fed into a primary coil and induces a voltage in a secondary coil, mounted just above the diaphragm. The form supporting the coils is mounted rigidly with respect to the fixed portion (the brass disk) of the cell. Mutual inductance between coils is therefore a function of diaphragm expansion and hence is indicative of gas pressure.



Accelerator Tests Aircraft Components

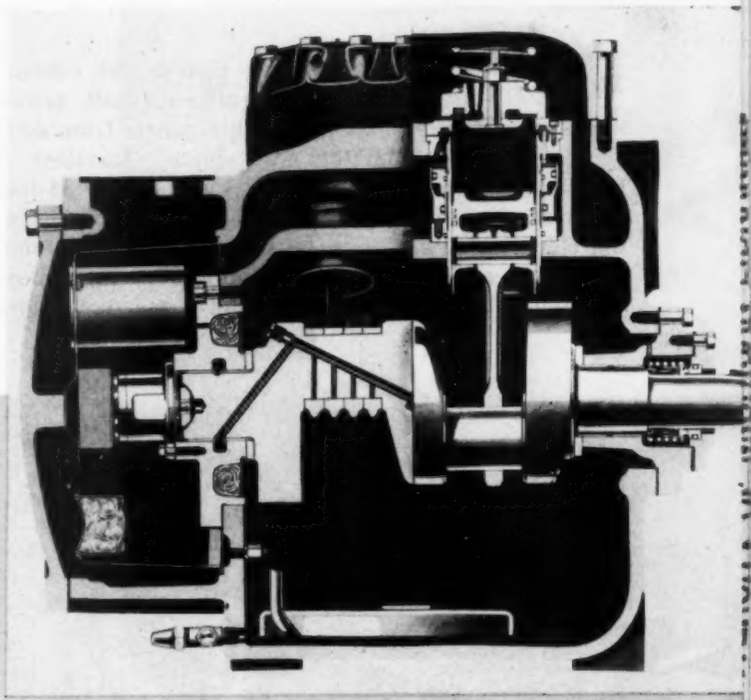
OPTICAL, pneumatic and electrical systems are neatly combined in the new "G" Accelerator, left, made by Genisco Inc. for testing aircraft and missile parts. The device applies a steady force of controlled magnitude to parts or assemblies for calibration or for observing functional behavior under simulated operating conditions. The object to be tested is secured to a mounting pad on the rotating arm and the arm bal-

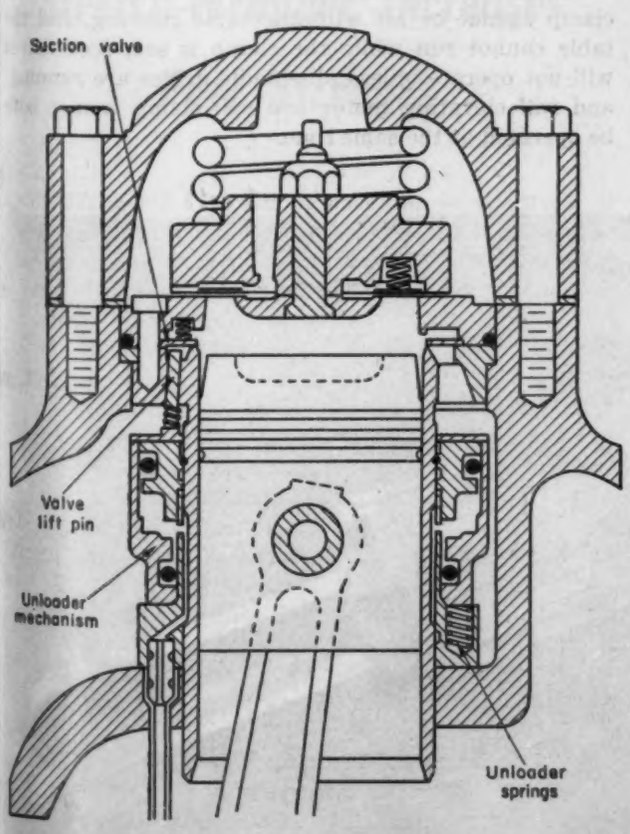


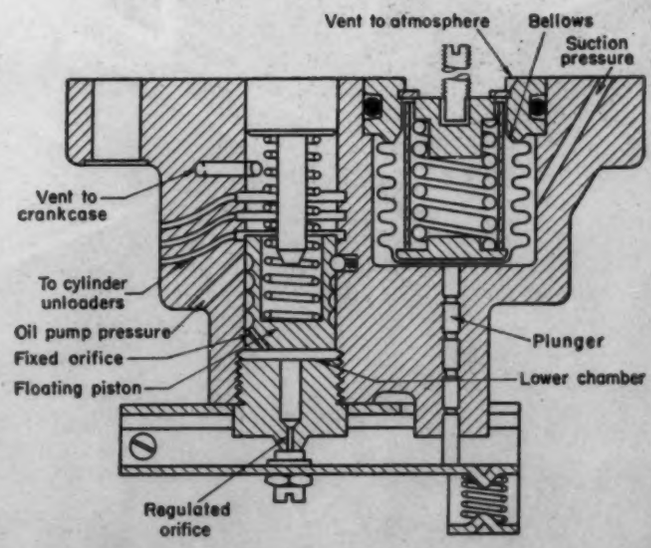
anced by an adjustable weight. Electrical leads and air connections are carried to the mounting pad through slip rings and an air gland arrangement, respectively, cutaway drawing opposite page. The test object can be seen by a telescope through a prism system and appears stationary at all speeds, permitting accurate observation of the part at any time during testing. Speed is determined by setting a timer to a practical time interval; the timer, in turn, supplies current to a revolution-counter clutch. This clutch, essentially a solenoid-actuated clutch-brake mechanism, couples the mechanical counter to the main drive shaft and counts revolutions for the time interval desired to permit accurate calculation of the rotational speed and therefore the gravitational load and acceleration.

Capacity Control System Regulates Compressor

INTERNAL control system in the new line of Trane Co. reciprocating compressors, cutaway view right, automatically adjusts capacity to demand through three stages of reduced-load operation. Capacity control is regulated by compressor suction and actuated by oil pressure. Until oil pressure is developed at start-up, unloader springs force the unloaders against a series of valve lift pins which are raised against the suction valves to keep them from seating. The drawing below, left, shows the mechanism in fully loaded condition. When oil is supplied to the unloader by the





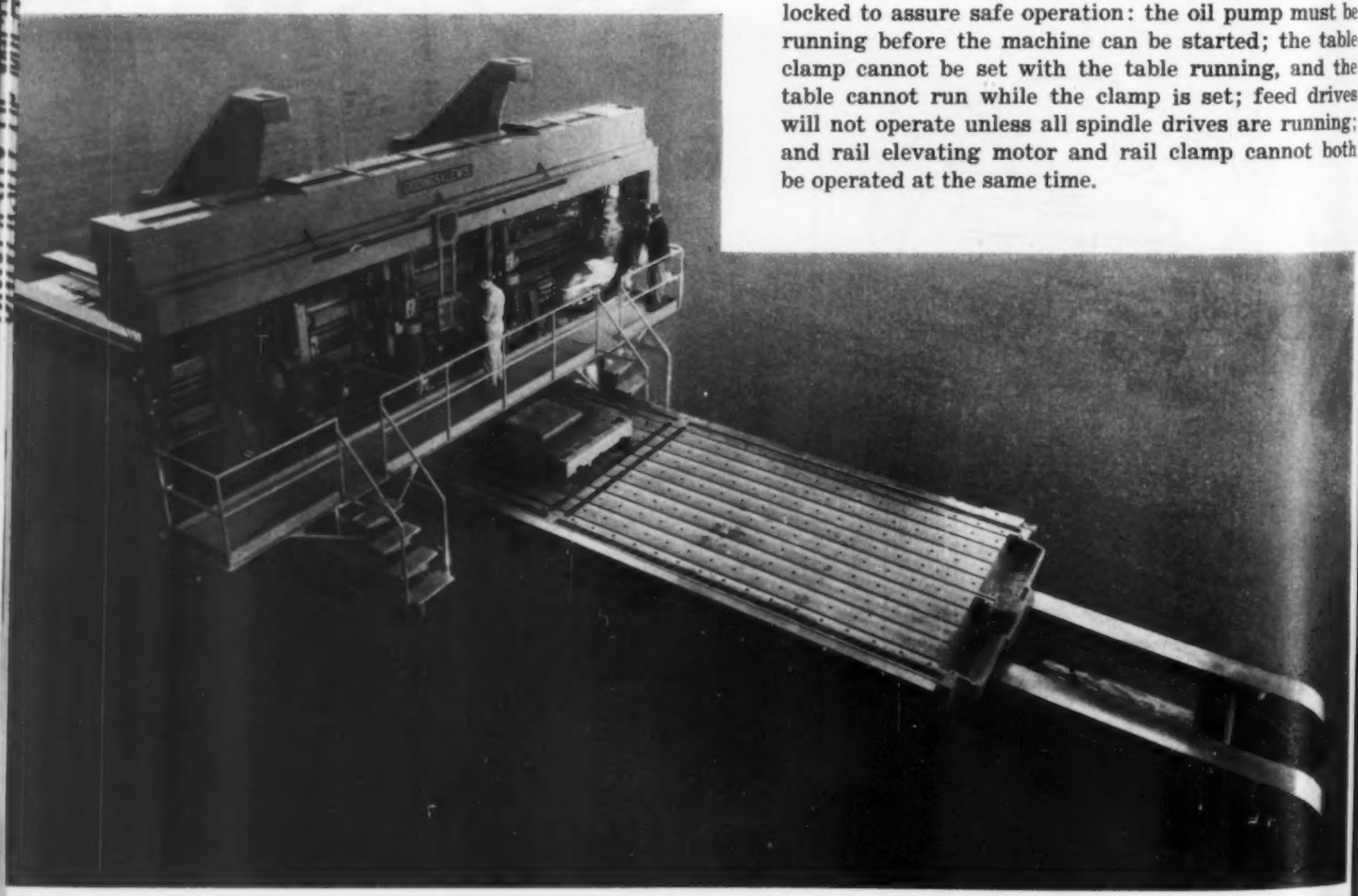


actuator, unloader-spring tension is overcome, the valve pins are retracted, and the suction valves can close. When suction pressure falls, indicating that less than full compressor output is needed, the capacity control actuator cuts off oil to one or more of the unloaders, thus reducing capacity.

A suction-pressure bellows controls the capacity actuator, drawing on the right, previous page. Contraction of this bellows under high suction closes an orifice in the chamber below a hydraulic cylinder. Pressure from the oil pump then builds up under the piston through a fixed orifice in the piston, forcing the piston up and opening oil passages between unloaders and the oil pump. As explained previously, this pressure to the unloaders allows the suction valves to operate normally. Expansion of the bellows under low pressure reverses the travel of the floating piston, cutting off oil to the unloaders and consequently reducing capacity of the compressor. Various capacities are provided for by intermediate positions of the floating cylinder, where only some of the unloaders are under oil pump pressure.

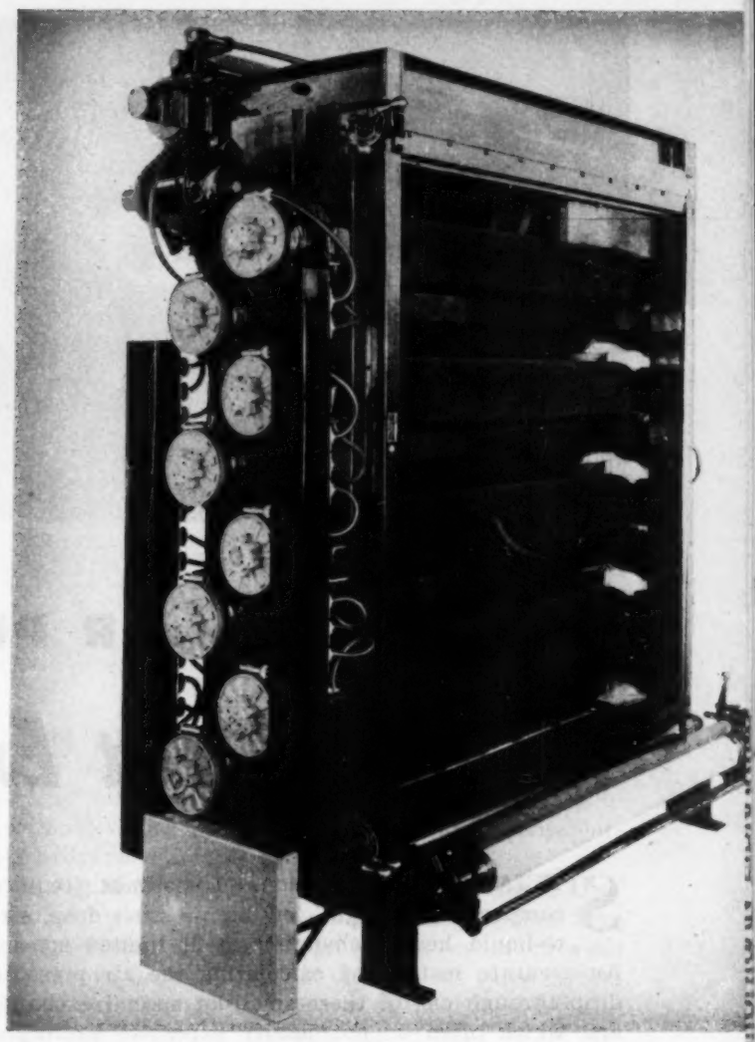
Tracer Miller Machines Aircraft Parts

LARGEST machine ever built with tracer control, the Giddings & Lewis aircraft skin mill, below, is designed to mill integral-rib skin panels from solid or rough-forged aluminum alloy plate. Installed at Lockheed, the machine has a work area 10 by 34 feet and manufactures airplane surfaces and their stiffening elements as a unit, permitting use of the thinner wings and sharper fuselages required for high-speed jet flying. The miller operates in three dimensions with two feed motions and is designed to work in a feed range from ¾-inch to 150 inches per minute with infinitely variable intermediate speeds. Two-dimension electronic tracer control is used to guide longitudinal and lateral cutting motions and a vertical rise-and-fall cutting action is incorporated to control variations in web thickness. Two of the three milling heads can be used simultaneously removing metal up to 600 cubic inches per minute. Trailing hoses and electrical lines are kept out of the way by feed reels in the overhead crossbeam section. Controls are completely interlocked to assure safe operation: the oil pump must be running before the machine can be started; the table clamp cannot be set with the table running, and the table cannot run while the clamp is set; feed drives will not operate unless all spindle drives are running; and rail elevating motor and rail clamp cannot both be operated at the same time.



Electric Brake Stops Cloth Brusher

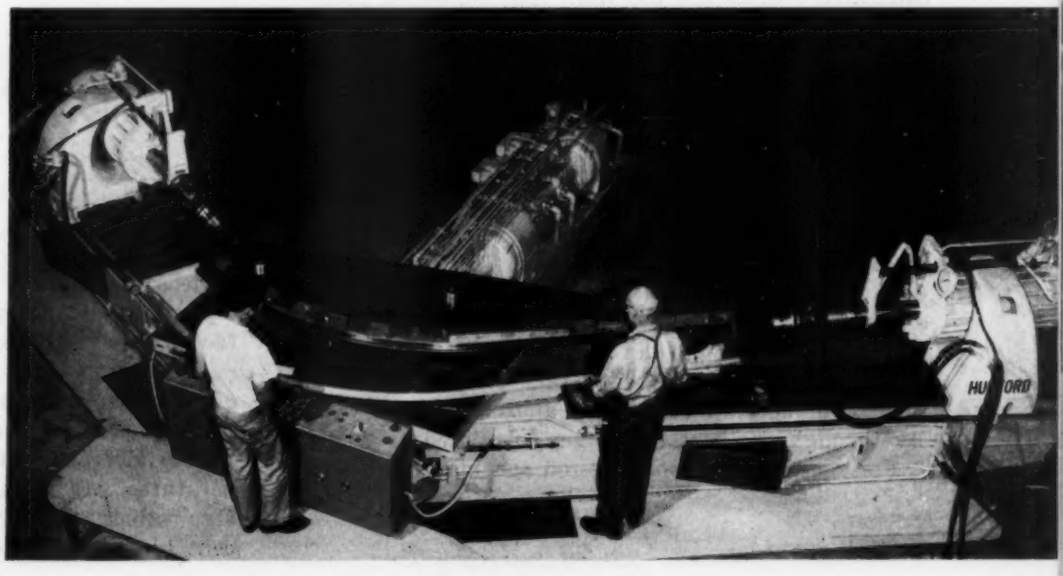
STOPPING of all eight brush rollers in the latest Hermas Machine Co. cotton cloth brushing machine, right, must be simultaneous to prevent tearing and piling up of material between rolls. The machine, composed of eight 8-inch diameter brush rolls, uses a Warner electric brake mounted on the end of each roll to permit smooth stopping in a fraction of a second. All brakes are controlled from a single power source, with each brake individually adjustable for stopping time by a simple rheostat. Since power consumption for the brakes is considerably less than required for plugging motors, a 1-hp motor can now be used on each roll in place of the 1½-hp motors previously required with the plugging stop.

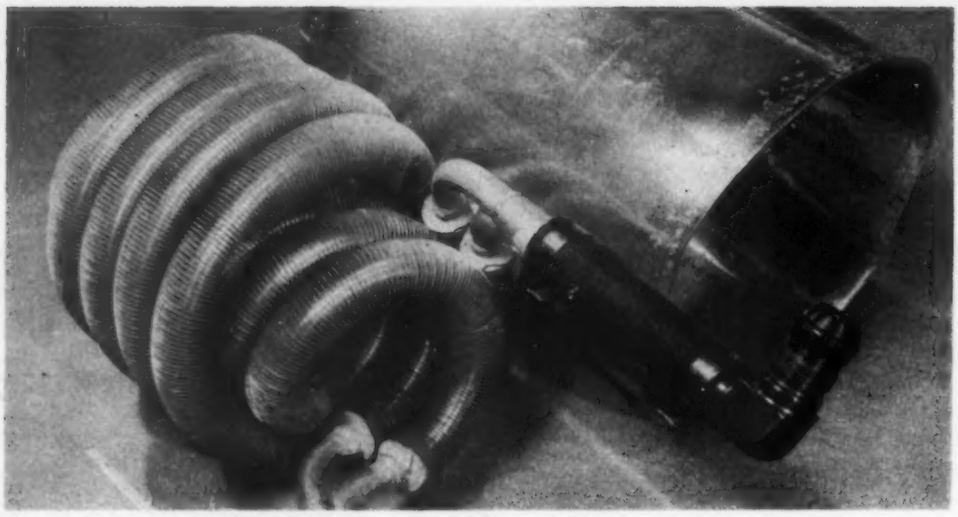


Stretch-Wrapper Increases Part Strength

STRETCH-WRAP forming machine in operation at Consolidated Vultee, below, is being used for precision forming of large aircraft parts. The new Hufford 60-ton machine takes advantage of the characteristic of certain metals, including aluminum, to become semiplastic when stretched beyond the elastic limit. In this operation, a contoured part is formed by first stretching almost to the yield point in front of a fixed die. With tension held, the part is wrapped around the die and accurately molded to the die configuration. Upon completion of the wrap, another stretch is applied with a tension slightly exceeding the elastic limit of the metal to produce the semiplastic condition.

This second operation or stretch "sets" the contoured shape to eliminate springback and raises the yield strength of the material. This machine handles lengths up to 304 inches and has a pull of 118,000 pounds. After completing its first cycle, the machine can be set for automatic operation.





By Richard E. Shafer
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CALCULATING AIR PRESSURE DROP OF *Heat Exchangers*

SPECIALIZED applications sometimes require compact, lightweight, low air pressure drop, air-to-liquid heat exchangers to fit limited spaces. An accurate method of calculating the air pressure drop through one of these small-lot special exchangers, which often do not justify expensive prototype tooling and testing, is outlined here.

Air pressure drop through heat exchangers has been the subject of much investigation, a great deal of conflicting and nonapplicable data being available. In this analysis, no factors are included for the effect of tubing fins. If the usual methods of considering the fins as a wetted surface for determining the hydraulic radius and pressure drop calculations are made on this basis, the results are far too high. If the exchanger is considered as a very rough tube, the calculated results are too low. The following procedure, originally outlined by Chilton and Genereaux in the Du Pont Experimental Station Contribution No. 127, has proved to be accurate within 5 per cent.

An exchanger using coiled finned aluminum tubing of $\frac{5}{8}$-inch ID, $\frac{3}{4}$-inch OD and $1\frac{1}{2}$-inch fin OD was used, of the type made by the Wolverine Tube Co. The cooling problem involved a closed container filled with 3.5 pounds of atmospheric air. This air was to be maintained at 115 to 150 F, with 700 Btu per minute to be removed from the contained air. The heat exchanger was to be mounted in this container and air circulated through the exchanger and container by means of a small high-speed fan. Proper mass flow of air was determined and the approximate air velocity through the heat exchanger calculated as 80 fps.

For rectangular, nonstaggered spacing,

$$\Delta P = \frac{4frU^2_{Max}N}{2G}$$

where the friction factor is calculated from

$$f = 0.33\ (dsU_{Max}\ r/V)^{-.2}$$

In these equations,

ΔP = Pressure drop, lb per sq ft
δ = Density of gas, lb per cu ft = 0.07 in this example
G = Acceleration of gravity = 32.2 ft per sec
U = Velocity at narrowest cross section, ft per sec, 80 in this example
V = Absolute viscosity, lb/sec ft units, 0.0000134 in this example
N = Number of tubing rows in depth of heat exchanger, 6 in this example
ds = Clearance between tubing rows normal to air flow, ft, 0.062 in this example.

Then

$$f = \frac{1(0.33)}{\left[0.062(80)\left(\frac{0.07}{0.0000134}\right)\right]^{.2}} = 0.043$$

$$\Delta P = \frac{4\ (0.043)\ (0.07)\ (6400)\ (6)}{64.4} = 7.18\ \text{psf} = 0.05\ \text{psi}$$

$$= 1.35\ \text{inches of water}$$

(The same method is used for staggered spacing except that the nonstaggered spacing has a friction factor only 44 per cent as great.)

Air pressure drops were measured with the aid of flow straighteners and ASME recommended techniques, and thermocouples used for recording water inlet and outlet and air inlet and outlet temperatures. In tests, the heat exchanger equaled design values, the air pressure drop being only 5 per cent higher than calculated by the method outlined.

Proportionalizing Dither

. . . increases sensitivity of hydraulic servo

By Paul B. Sebring

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ON-OFF or two-position servomechanisms in which full torque is always developed by the servomotor, either in one direction or the other, are attractive because they are simple and cheap and, if the inherent hunting oscillations can be tolerated, the positioning accuracy is good. In an electrical system of this type the final power amplifier is usually a relay, whereas for a proportional electrical system of the same power capabilities the power amplifier is usually an amplidyne generator or a large electronic amplifier.

A method of linearizing an on-off system by inserting a "proportionalizing dither" signal into the servo loop is coming into increasing use. This article will discuss the means by which this dither voltage linearizes an on-off system and will describe the application of this principle to an hydraulic system using simple on-off solenoid-operated spring-released reversing valves instead of the expensive, precise proportional valves normally employed for a nonoscillating hydraulic servo.

In *Fig.* 1 is shown a schematic circuit for a two-position hydraulically-powered positioning system. The characteristics of this amplifier and valve are such that, above the critical input voltage, the valve directs the oil flow to one side of the piston but, when the input voltage drops through the critical value, the valve quickly reverses and directs oil to the opposite side. Such a system will oscillate continuously at a frequency largely determined by the inertia of the load and the force available from the actuator piston, assuming no hysteresis in the valve action and neg-

Fig. 1—Two-position oscillating servo system

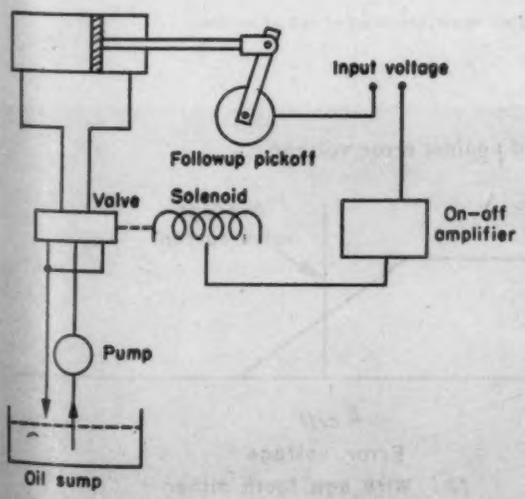
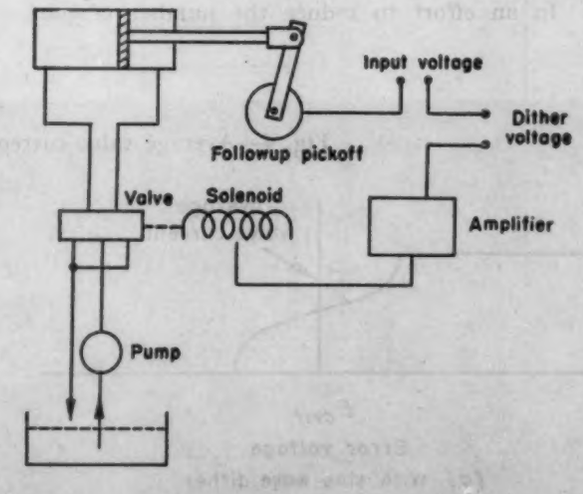


Fig. 2—Dither linearized servo system



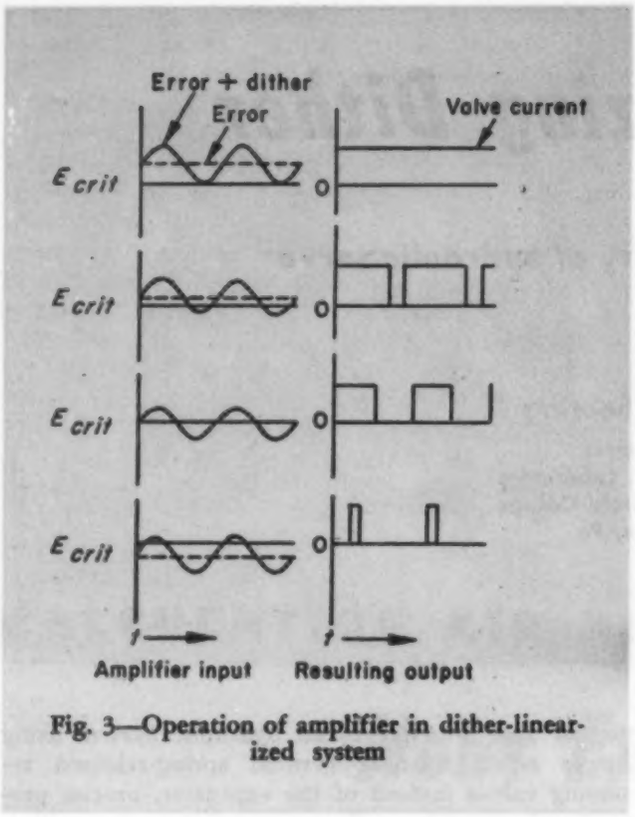


Fig. 3—Operation of amplifier in dither-linearized system

lecting the inertia of the valve spool itself.

Such a system is adequate for many applications. Indeed, for the positioning of rudders and similar loads, it has advantages over the smooth-operating conventional proportional system since static friction never has the opportunity to interfere with the movement of the load. In many other applications, however, the steady-state oscillation cannot be tolerated. The proportional servo which must be used in such cases is usually considerably more complicated and expensive. Hydraulic valves for proportional operation are particularly delicate and difficult to construct.

Development of this dither system was brought about partly by the fact that a proportional hydraulic servo was needed in one portion of a larger system which already included several two-position hydraulic servos. In an effort to reduce the number of part types it was decided to attempt an adaption of the "proportionalizing dither" or "carrier" technique to a two-position servo of the same type to obtain the desired control. A block diagram for such a system appears in *Fig.* 2.

The dither-linearized system differs from the two-position system only in that an alternating voltage is introduced into the servo data loop. This voltage has a frequency substantially higher than the natural frequency of the system and a magnitude determined by the system gain or "stiffness" desired. Operation of such systems has been explained and analyzed by MacColl[1] and Lozier[2], but it may be worth while to review the basic idea in this article. In order to understand better the effect of adding dither voltage, reference to the sketches in *Fig.* 3 will be helpful. The curves on the left show amplifier input voltage, which consists of the dither voltage superimposed on the error voltage from the data system, while the sketches on the right show the resulting current to the valve. The amplifier characteristic is such that, as long as the input voltage remains above the reference value E_{crit}, full current flows through the valve while, during any time that the voltage is below this critical value, the valve current is cut off.

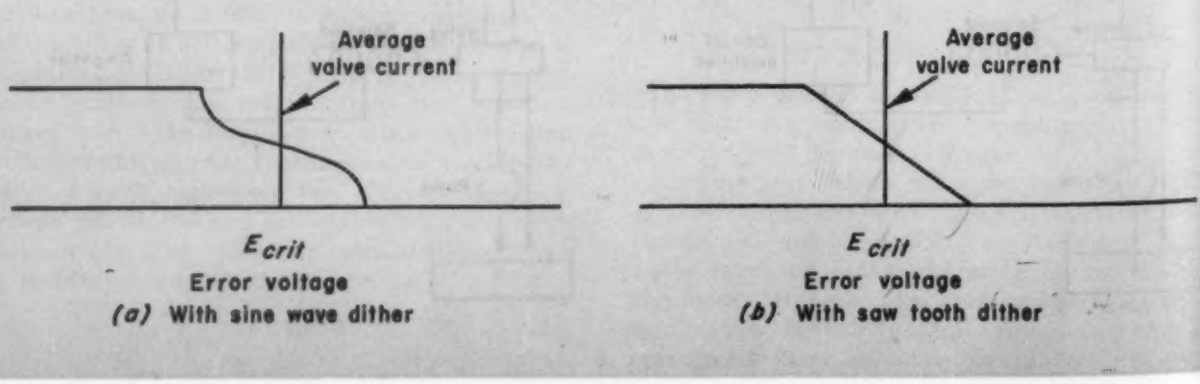
The top pair of sketches, *Fig.* 3, shows a condition in which the error voltage is greater than the peak value of the dither voltage. Successive sketches show progressively lower error voltages so that the resulting input voltage drops below the critical voltage for increasing proportions of the dither cycle. It is easily seen that, under these conditions, the average valve current is a smooth function of the error voltage for the interval in which the error voltage does not deviate from the critical input voltage by more than the peak value of the dither.

Dither Amplitude Controls System Gain

Study of *Fig.* 3 will also show that the steepness and shape of the valve current curve is a function of the dither amplitude and wave shape. This is a most significant fact since it means that the dither amplitude controls the effective system gain or stiffness. *Fig.* 3 was drawn to illustrate the use of sine-wave dither. This would give an average valve cur-

1. References are listed at end of article.

Fig. 4—Average valve current plotted against error voltage



rent versus error voltage function similar to *Fig. 4a*. The ideal dither wave form would be a triangular or saw tooth wave and would give a linear valve current function similar to *Fig. 4b*.

Since it is known that average valve current is a smooth function of the error voltage over a certain range, the problem consists in obtaining this average from the actual current wave form.

In an electric circuit which has a relay as the final power amplifier, the averaging must be done by the inertia of the motor and its load. This postulates a dither frequency only sufficiently high so that the motor and load cannot respond appreciably to the dither.

In the hydraulic system the averaging can take place either at the motor and load as in the electric system, within the control valve itself or to some extent in each.

The control valve has a response which is a function, on take-up, of the net solenoid pull and, on release, of the spring restoring force. The less the mass of the valve spool and solenoid plunger and the larger the forces, the more rapid is the response. If a dither frequency is chosen sufficiently low that the valve spool can approximately follow the current wave, the condition exists in which the oil is fed to the motor in pulses and the averaging must be done by the load inertia. In operation such a system may vibrate rather heavily, imposing severe strains on structural members, shaft couplings, etc.

If simplifying assumptions are made so that for equilibrium valve current the net solenoid pull is constant over the valve spool travel and is equal to the restoring force of the spring at midtravel, the resonant frequency of the valve can be calculated easily. It can further be shown that the response of the valve spool to an exciting frequency drops off rapidly after the frequency exceeds that for resonance. It might seem attractive, therefore, to raise the dither frequency into this region and let the averaging occur in the valve. Thus the load and motor would be relieved of most of the vibration.

In the laboratory this system has operated successfully in this mode. Vibration is almost nonexistent and the system is, for practical purposes, proportional. In making a field design, however, this mode of operation was not chosen for the following reasons:

1. Most simple on-off reversing hydraulic control valves are less carefully built than proportional valves and, therefore, in spite of the small amount of vibration to which the spool is still subjected, the dynamical lubrication is insufficient to prevent the valve from sticking at times, thus making the system unstable.
2. The usual on-off valve by no means satisfies the

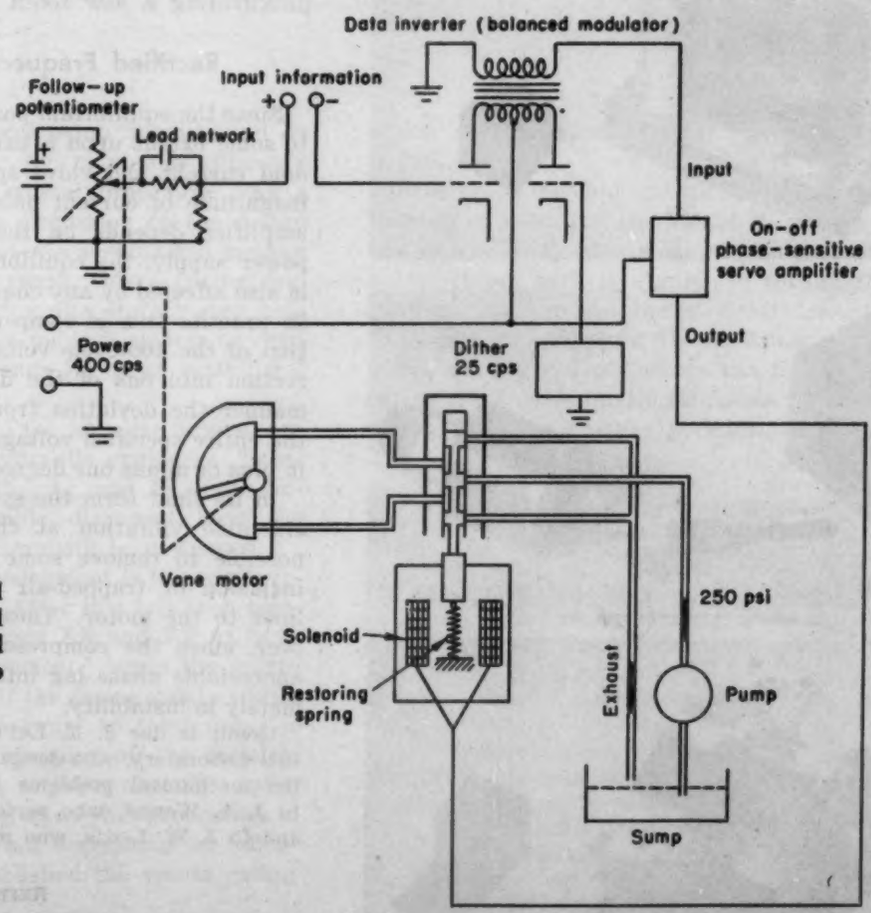


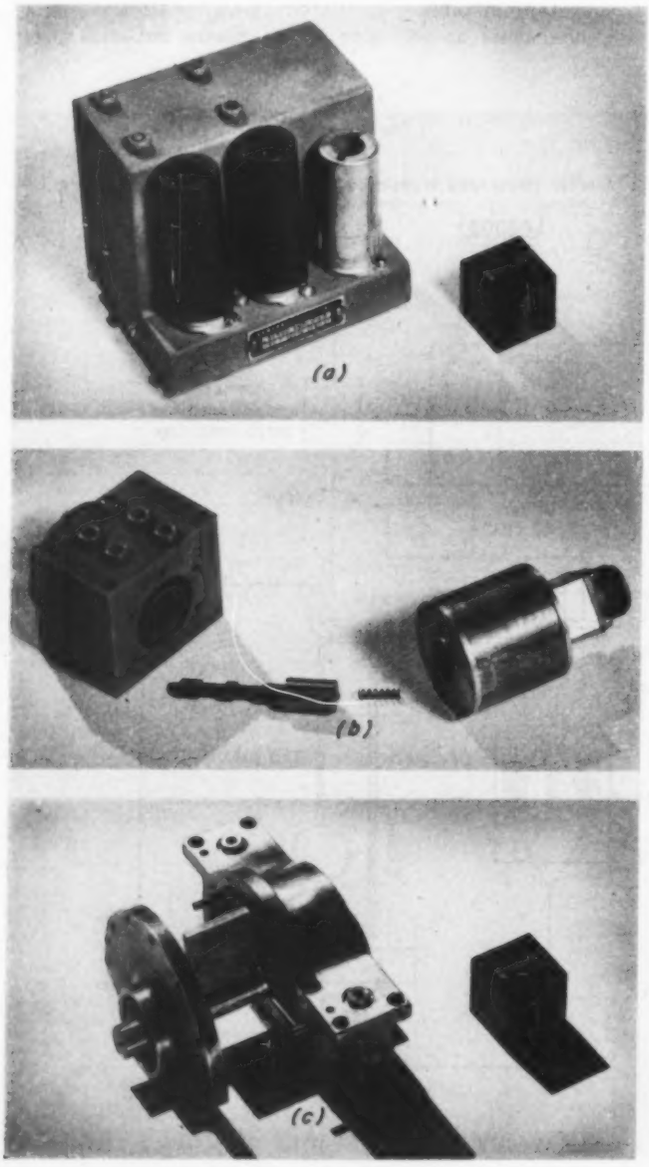
Fig. 5 — Partial schematic of final dither - linearized hydraulic servo

condition that the pull of the solenoid be uniform over the valve travel or that it be twice as strong as the restoring spring. This means that special tailoring of the solenoid gaps and careful adjustment of the valve spring are required to assure satisfactory operation. Equilibrium position of the system is markedly affected by the valve-spring tension.

The mode of operation of the system developed for the field is one in which only a portion of the averaging takes place in the valve. The dither frequency was set by experiment to the highest value at which valves consistently did not stick. Under this condition, the vibration in all parts of the system is sufficient to minimize the effects of static friction. At this frequency, which turned out to be 22-28 cps, the balance point of the servo is still affected to some degree by the stiffness of the valve restoring spring. Thus, if a valve is changed, the calibration of the system must be checked.

A partial schematic diagram of the final system developed for this application appears in *Fig.* 5. The input data is in the form of a d-c voltage in the range between plus and minus 8 volts. The power available for servo amplifier operation is 90 to 110 volts a-c at frequencies from 370 to 410 cps. The servo amplifier is of the phase-sensitive type, conducting for in-phase input and cutting off for out-of-phase input, so that the d-c error voltage must be inverted to a-c phase information before feeding to the amplifier.

Fig. 6—Important components of the final servo system showing the phase-sensitive amplifier at *a*, hydraulic valve at *b*, and hydraulic vane type actuator at *c*



Employs Vane Type Motor

For driving the load, a vane-type rotary hydraulic motor is used. A picture of this motor, together with the control valve and amplifier, is shown in *Fig.* 6. The load to be driven is a heavy weight which must be positioned on the end of a lever arm pressed onto the splined shaft of the motor. To enhance the stability of the system in the presence of such a large load inertia, a lead network is included immediately following the follow-up potentiometer. This lead network affects only the follow-up voltage and not the input voltage which, though nominally d-c, contains some unrelated frequency components which cannot be completely eliminated by filtering.

Whereas the dither voltage would ordinarily be included directly in the data system, the extra grid on the data inverter in this system makes an ideal place for the injection of this voltage. A multivibrator is used for the dither oscillator. It is followed by some filtering with a resulting wave shape approximating a saw tooth with rounded corners.

Rectified Frequency Corrects Error

Since the equilibrium position of the system depends to some extent upon a balance between average solenoid current and valve spring tension and since the magnitude of current pulses fed to the valve by the amplifier depends on the voltage of the 400-cycle power supply, the equilibrium position of the system is also affected by any change in the 400-cycle voltage. In practice this is compensated by rectifying a portion of the 400-cycle voltage and feeding it as a correction into one of the data inverter grids. In this manner the deviation from the correct position over the entire specified voltage range has been kept within plus or minus one degree.

In its final form the system is still subject to considerable vibration at the dither frequency. It is possible to remove some of the oil-hammer by the inclusion of trapped-air chambers in the hydraulic lines to the motor. These must be kept small, however, since the compressibility of air can introduce appreciable phase lag into the system, resulting ultimately in instability.

Credit is due J. E. LeFrancois and D. C. Garland of this Laboratory, who designed the vane motor and solved the mechanical problems incidental to the mechanism, to J. A. Wenzel, who performed much of the test work, and to J. W. Lewis, who made helpful suggestions.

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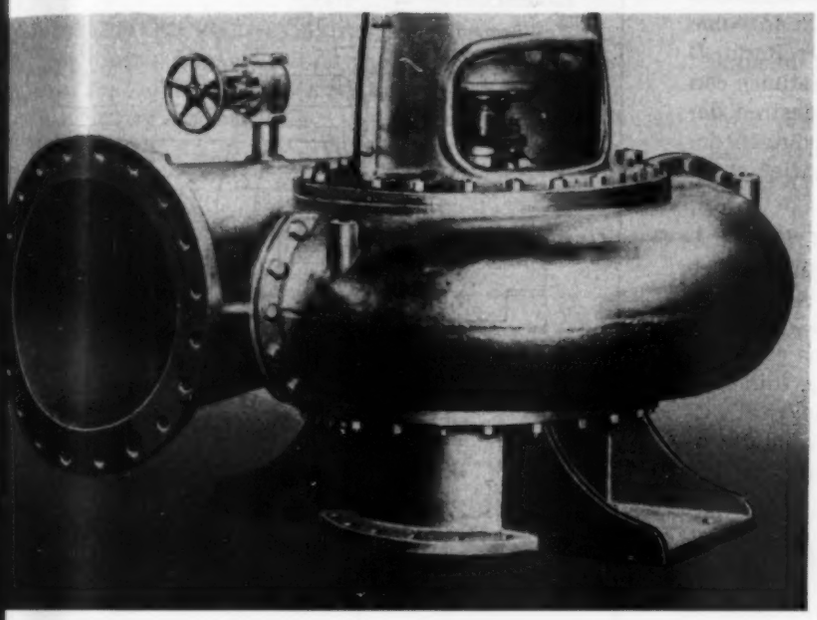
2. J. C. Lozier—"Carrier Controlled Relay Servos," *Electrical Engineering*, Dec. 1950.

HOW TO LAY OUT Centrifugal Pump Volute Casings



By Edward G. Hilficker

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DESIGNING a centrifugal pump impeller and its mating volute casing for maximum efficiency is an exacting and critical procedure. As a logical sequel to a previous discussion on the design of impellers† this article presents a simplified method for developing centrifugal pump volute casing and discharge sections. Following the step-by-step procedure outlined should enable pump designers to complete necessary casing drawings for most centrifugal pumps.

Casing data, in addition to the impeller figures, are usually submitted by the hydraulic engineer. These data should include A, w, D_{cw}, t_{cw} and D_D, (see Nomenclature). In the example discussed here the volute casing for a 3-inch pump will be developed.

The first step in volute development is the construction of the impeller profile. After this has been completed, on the same center-lines XX and YY as were used for the impeller development,† begin the volute section development, *Fig.* 1. If the casing volute width, w, is not supplied, make it equal to total impeller width plus $2 \times 0.03\ D_2$ by stepping off the distance $0.03\ D_2$ on either side of the impeller shroud. Judgment must be used in setting w as this proportion is merely a rule of thumb and not necessarily an inflexible limitation. Having established the volute casing width, draw vertical construction lines through these points.

Proceed to develop the throat or cutwater section, bearing in mind that the height H_8 should be equal to the width W, or nearly so. The square root of the volute throat area is a guide in setting the first approximation for the linear dimensions W and H_8. Note that the cutwater tip thickness must be determined and spaced off before the H_8 dimension is located. This cutwater tip thickness should be made as thin as foundry practice permits. Use $D_D/2$ for the

Nomenclature

A = Volute throat area
D_2 = Impeller outside diameter (base circle)
D_{cw} = Casing cutwater diameter (casing "tongue") = 1.07 D_2 (average)
D_D = Diameter of pump discharge nozzle
H = Volute section height
r = Volute small radius
$r_{1\text{-}0}$ = Volute large radius
R = Volute section small radius
r_1 = Volute section large radius
R_1 = Cutwater tip-to-casing radius
t_{cw} = Cutwater tip thickness
W = Casing volute width
w = Volute section width

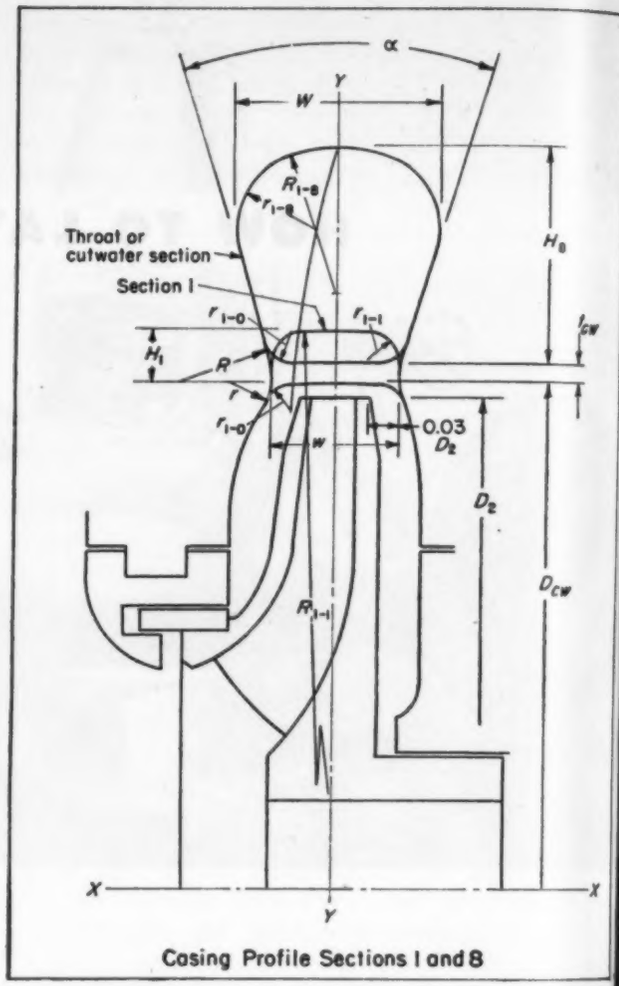
† E. G. Hilficker—"How to Lay Out Centrifugal Pump Impellers," MACHINE DESIGN, November, 1950, Pages 137-142.

large radius R_{1-8} and sketch a smooth curve to locate the center of the small radius r_{1-8}. Then swing an arc, centered on this curve and tangent to both the curve of radius R_{1-8} and the approximated width W. Draw the sides of the section by connecting the R and r_{1-8} curves with a tangent line and check the throat area using a planimeter. If the area is not near enough to the desired figure, a slight modification must be made to the height or width, or both. With a little care, plus experience, it is possible to come fairly close with the first approximation. Radii R and r are established by inspection and sometimes can be equal so that one sweep will give the desired design. Again, watch that the angle α is about 45 degrees, as this has been found the most satisfactory for an efficient volute.

FIRST VOLUTE SECTION: In establishing section 1, it is necessary first to determine the required area. Assuming that the volute casing desired is to be of the constant-velocity type, the area section 1 is A_1 = (Volute throat area × 45)/360, if sections every 45 degrees are to be developed. By dividing this area by the casing width w, which is also the width of section 1, a height H_1 is determined. This should be increased a small amount to compensate for the slight arch and corner radii.

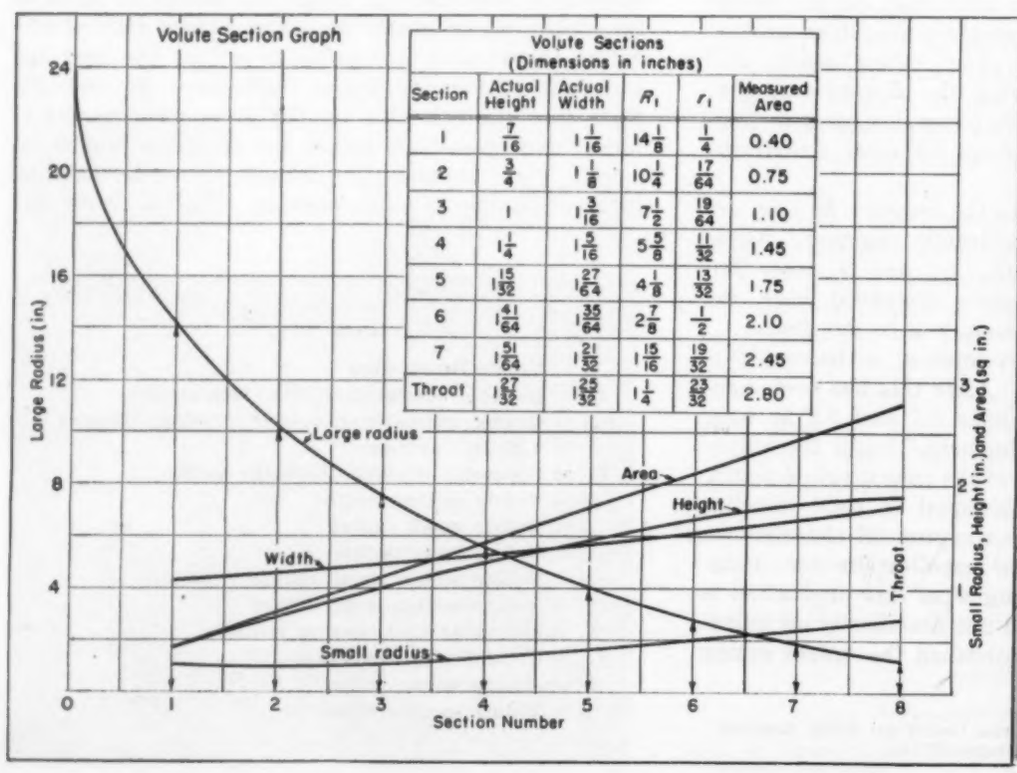
Graph Helps Determine Radii

The next step is to determine a large radius R_{1-1} to give a gradual change between the cutwater, which is flat, and the slight arch of section 1. It is helpful to draw a graph showing values of the large radius at all sections, *Fig.* 2. First, set the two extremes: The cutwater section, where the radius is infinity, and section 8 where $R_{1-8} = D_D/2$. In order to connect these points with a smooth curve, assume a radius for



Casing Profile Sections 1 and 8

Fig. 1—Above—Casing volute development is started with sections 1 and 8 on same center lines used for impeller development



Volute Sections (Dimensions in inches)

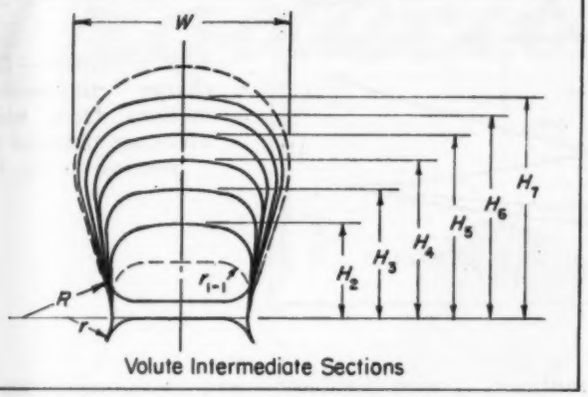
Section	Actual Height	Actual Width	R_1	r_1	Measured Area
1	$\frac{7}{16}$	$1\frac{1}{16}$	$14\frac{1}{8}$	$\frac{1}{4}$	0.40
2	$\frac{3}{4}$	$1\frac{1}{8}$	$10\frac{1}{4}$	$\frac{17}{64}$	0.75
3	1	$1\frac{3}{16}$	$7\frac{1}{2}$	$\frac{19}{64}$	1.10
4	$1\frac{1}{4}$	$1\frac{5}{16}$	$5\frac{5}{8}$	$\frac{11}{32}$	1.45
5	$1\frac{15}{32}$	$1\frac{27}{64}$	$4\frac{1}{8}$	$\frac{13}{32}$	1.75
6	$1\frac{41}{64}$	$1\frac{35}{64}$	$2\frac{7}{8}$	$\frac{1}{2}$	2.10
7	$1\frac{51}{64}$	$1\frac{21}{32}$	$1\frac{15}{16}$	$\frac{19}{32}$	2.45
Throat	$1\frac{27}{32}$	$1\frac{25}{32}$	$1\frac{1}{4}$	$\frac{23}{32}$	2.80

Fig. 2—Left—Various linear dimensions at each section are developed on this graph, which is also used to check smooth progression of section areas

the center section 4, R_{1-4}. This radius can be set equal to $D_{cw} + \frac{1}{2}H_8$. With these three points, a curve can be drawn, *Fig.* 2, to determine the large radius for each section.

Having the area, width, radii, and an approximated height for section 1, develop this section as in *Fig.* 1. Then check its area with a planimeter, correcting if necessary by altering the height until the desired area is obtained.

INTERMEDIATE VOLUTE SECTIONS: After establishing the linear dimensions of the first and last sections of the volute, the intermediate sections are readily determined by completing the graph, *Fig.* 2.



Volute Intermediate Sections

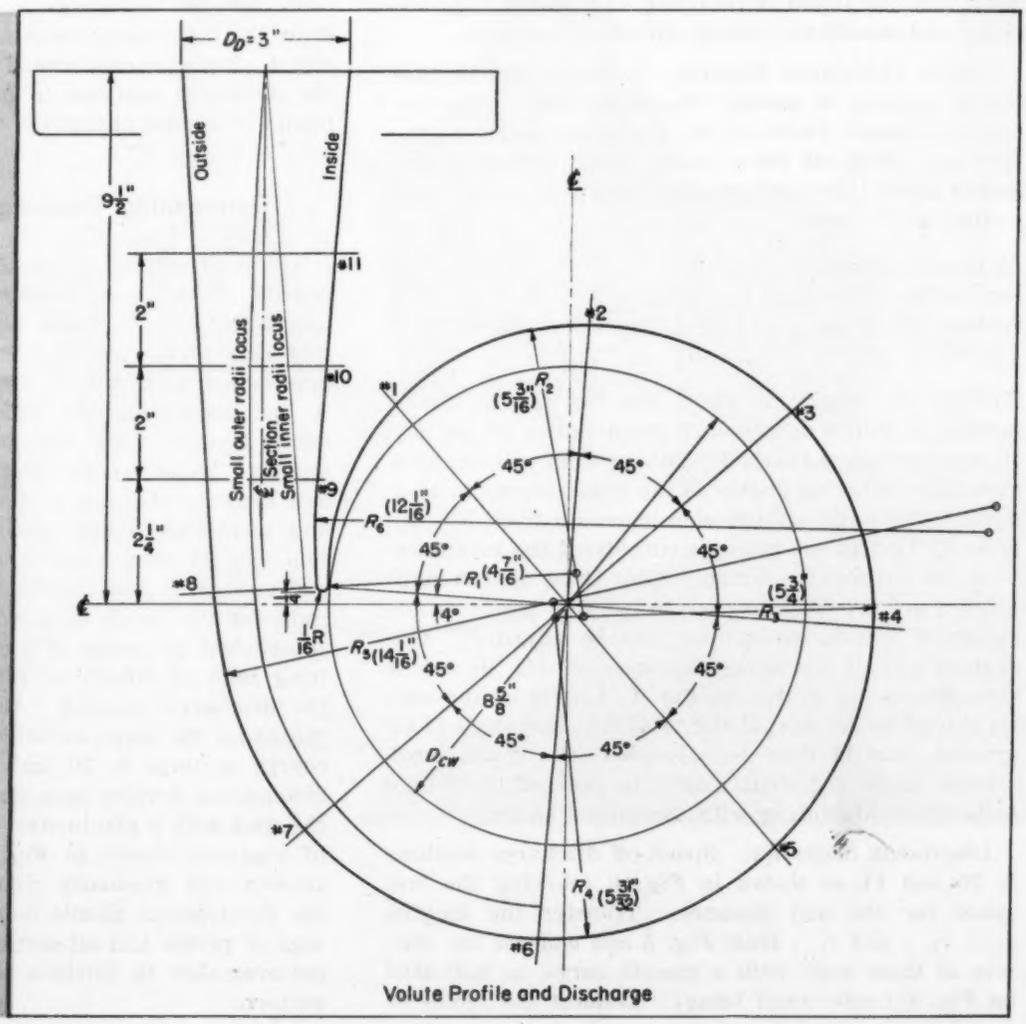
Using any convenient scale for height, width, and small radius, set definite dimensions for all intermediate sections, regardless of the number of sections included in the particular design. After drawing the respective curves, tabulate the dimensions in chart form for convenience, *Fig.* 2. Then the sections may be drawn as shown in *Fig.* 3 and checked for area. These areas should be plotted on the graph, *Fig.* 2, to assure a smooth, gradually increasing area curve.

Sudden Section Changes Decrease Efficiency

Care must always be exercised in the design of a volute casing to insure that no sudden changes in sections are created. Any such change may decrease pump efficiency. If the areas and sections are acceptable, the next step is to transfer the respective section heights onto the volute profile, *Fig.* 4. These heights are measured radially from the cutwater diameter circle.

VOLUTE PROFILE: After spacing off the radial dimension at each section line, connect the end points with a series of radii trying to extend each radius through no less than three points. Referring to *Fig.* 4, note the location of the centers from which the radii are swung; each succeeding point moves closer to the shaft center except R_6, where the liquid leaves the volute and enters the discharge channel. Special

Fig. 3—Above—Areas of these volute intermediate sections are determined by planimeter and plotted in *Fig.* 2 for checking



Volute Profile and Discharge

Fig. 4—Right—Volute profile is determined by transferring section heights from *Fig.* 2 to cutwater diameter circle. Discharge profile is developed from *Figs.* 5 and 6

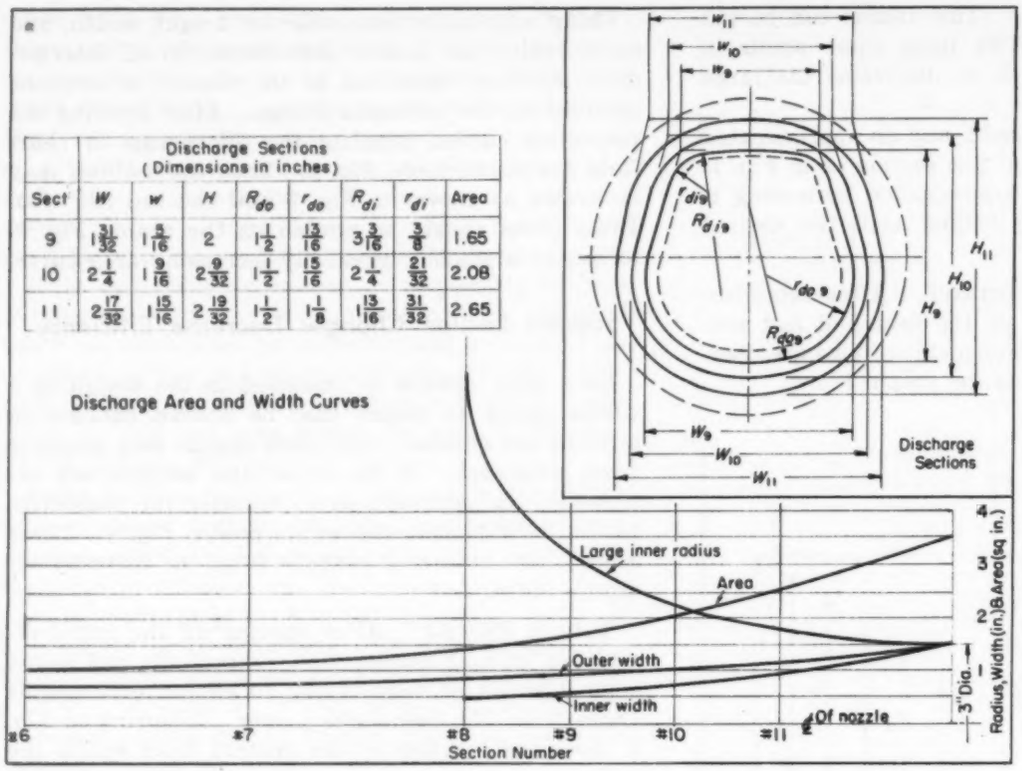

Discharge Sections
(Dimensions in inches)
Sect | W | w | H | R_{do} | r_{do} | R_{di} | r_{di} | Area
9 | $1\frac{31}{32}$ | $1\frac{5}{16}$ | 2 | $1\frac{1}{2}$ | $\frac{13}{16}$ | $3\frac{3}{16}$ | $\frac{3}{8}$ | 1.65
10 | $2\frac{1}{4}$ | $1\frac{9}{16}$ | $2\frac{9}{32}$ | $1\frac{1}{2}$ | $\frac{15}{16}$ | $2\frac{1}{4}$ | $\frac{21}{32}$ | 2.08
11 | $2\frac{17}{32}$ | $1\frac{15}{16}$ | $2\frac{19}{32}$ | $1\frac{1}{2}$ | $1\frac{1}{8}$ | $1\frac{13}{16}$ | $\frac{31}{32}$ | 2.65
Discharge Area and Width Curves
Large inner radius
Area
Outer width
Inner width
3" Dia.
Radius, Width (in.) & Area (sq in.)
#6
#7
#8
#9
#10
#11
℄ Of nozzle
Section Number
Discharge Sections

Fig. 5—Curves used to determine outer and inner widths and large inner radii of discharge sections. Area progression curve is also shown

Fig. 6—Insert — Discharge intermediate sections from which areas are obtained for plotting in *Fig.* 5

emphasis must be placed on the shape of the cutwater tip. This tip should be streamlined; bear in mind that the liquid is traveling at a rather high velocity and should not change direction suddenly.

CASING DISCHARGE NOZZLE: Diameter of the discharge section is usually the pump size. Approximate the inside limits of the discharge nozzle by inspection. Step off three spaces from section 8, two inches apart. Mark off an approximate height at each section as follows:

Section $9 - 2(\tan 5\frac{1}{2}^\circ) + H_8$
Section $10 - 2(\tan 5\frac{1}{2}^\circ) + 2(\tan 8^\circ) + H_8$
Section $11 - 2(\tan 5\frac{1}{2}^\circ) + 2(\tan 8^\circ) + 2(\tan 11^\circ) + H_8$

Continue to repeat the third step for any necessary number of 2-inch spaces until the diameter of the discharge opening is reached. This process will assure a gradually widening profile as the liquid begins to slow down. The angle of diffusion increases from $5\frac{1}{2}$ degrees to 11 degrees, which is considered the maximum limit for a discharge nozzle. After these approximate heights are set down in their respective positions, location of the flange opening can be adjusted. The centers of all discharge sections should lie on a straight line, or nearly so, *Fig.* 4. Length of the nozzle should be set so that the total diffusion angle is no greater than 11 degrees. However, the nozzle must always be of sufficient length to prevent the flange bolts from interfering with the volute casing.

DISCHARGE SECTIONS: Space off discharge sections 9, 10 and 11 as shown in *Fig.* 4, allowing the last space for the odd distance. Transfer the lengths r_{1-8}, r_{1-7} and r_{1-6} from *Fig.* 3 and connect the centers of these radii with a smooth curve, as indicated on *Fig.* 4 (outer radii locus). Connect the center of radius r_{1-8} with a smooth curve to the centerline of the discharge opening to establish the outer corner radii for the discharge sections. In like manner, draw the inner radii locus for the discharge sections, *Fig.* 4. These curves should guide the development of the discharge sections to prevent the occurrence of bumps or sudden changes.

Determining Discharge Section Widths

The next step is to establish the discharge section widths. This is done as shown in *Fig.* 5. Step off the spaces between sections horizontally on a common centerline and space off, vertically, the widths already determined, namely 6, 7, 8 and the discharge opening. A line connecting the first three will indicate the curve necessary to complete the discharge section widths. Make certain that all changes are gradual and smooth, starting with a low angle at section 8 and increasing slowly until near the discharge section. In the same manner, set down the inner widths and connect 8 and the discharge section. The large radii for the inside of the discharge sections may be established by means of a curve, *Fig.* 5, between limiting radii of infinity at section 8 and $1\frac{1}{2}$ inches at the discharge opening. Use the discharge opening radius for the large radii on the outer side of the discharge sections 9, 10 and 11. After tabulating all dimensions, develop each discharge section, measuring the area with a planimeter, and check the progression of areas as shown in *Fig.* 5. If the area curve is smooth and gradually rising toward the discharge, the development should be completed. Pattern drawings of profile and all sections should then enable the patternmaker to produce the required volute casing pattern.

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Engineering for Producibility

HOW TO ORGANIZE AND DESIGN FOR LOWEST COST

By Roger W. Bolz
Associate Editor, Machine Design

Basic cost levels are engendered in the engineering department. Attainment of real production economy and material savings requires proper organization and a good program of producibility education

Official U. S. Navy Photograph

Fig. 1—Program of cost control assures that poor designs are not released; that every part is adequately producible under conditions prevailing at release

SETTING UP THE ORGANIZATION

THE descriptive term "poor design", generally applied to mechanisms which fail to function properly or adequately, can just as well be used to label units found to be impractical or expensive to manufacture. In most instances, components which prove costly to produce are taken for granted. Similarly, many that have been manufactured in one specific manner for years are unquestioned. If service life is reasonable and there are few shop problems, no demand develops for re-evaluation of design.

On what basis, then, can a design be judged as poor or good? Too, how can engineering management be assured that poor designs are not released—that every component is adequately producible under the conditions prevailing at release? At least fair to good assurance can be had if adequate attention is given this problem at the engineering-management level, *Fig.* 1. Even moderate schooling of designers in this all-important phase of design can produce real dollars-and-cents return.

Critical need for Producibility: Under normal manufacturing conditions, low-cost design is a vital factor necessary to meet competition. Where increased production for defense and possible emergency is concerned, it is a "must" for conservation of materials, maximum output and maximum speed as well as minimum cost. Organization for maximum producibility now is assuming a greater importance than ever before.

Where Will Producibility Pay? That any machine part designed or in production can be redesigned to

Fig. 2—Rapid developments in manufacturing techniques have made it extremely difficult for the designer to become well-versed in all pertinent details

Photo, courtesy GMC Truck & Coach Division

effect lower manufacturing costs is no longer a matter for debate. This has been proved in so many instances that today it is difficult to understand the complacency with which poor designs are often accepted. Granted, therefore, that cost savings are possible, what general typical advantages can be anticipated?

It has been found in the heavy-machinery, nonrepetitive, small-lot, and special machine fields that cost reductions which could be effected with an organized program ranged up to 10 per cent on an entire machine. Savings found possible on individual parts, of course, are often far greater. However, with repetitive production of fairly standardized products such as electric welders, transmissions, farm machinery, etc., reductions of 10 per cent *per year* on most components, regardless of labor cost, are typical. These ultimate results have established the fact that design sets up the minimum or basic costs beyond which only relatively minor savings are possible of attainment.

Program for Cost Control: Two vital ingredients are necessary to spark a realistic program for cost control: First, imagination and design ingenuity and, second, basic knowledge of production methods and manufacturing techniques. The first priceless ingredients are difficult to find in abundance, but every designer has these characteristics in some degree. Engineering management must seek by incentive—and it must be recognized that incentives consist of factors far more complex than mere monetary return[1]—to develop this latent ability to the greatest extent possible. The second ingredient normally is not present to any great degree for many reasons. The important factor is that full knowledge *is* available. It merely takes a positive program on the part of management to put these precepts into effect to whatever degree is found desirable.

Several primary reasons for instituting a planned production design program of one type or another are present. In the prevailing state of development in manufacturing techniques, *Fig.* 2, it is extremely difficult for any designer to become well-versed in all details and ramifications. Considering the broad overall coverage of common production methods, it is almost impossible for anyone to keep at fingertips all the specific detailed data necessary to design for low cost. Because of the rapidly expanding field of machine design, there is hardly time for specialists to gain the necessary experience to man adequate production-design groups. Hence, it has proved desirable to organize specific engineering programs to this end.

Effective Programs: What type of engineering program to employ for obtaining manufacturing economy depends upon many factors. Perhaps first among the basic considerations comes the particular company, its management and the caliber of the design engineers involved. In the main, no one hard-and-fast rule seems to be applicable; no one system is ideal for all conditions. Some of the most successful plans will be generally outlined in the following paragraphs.

DESIGN-COST GROUPS: In large engineering departments with many integrated basic divisions, the method of setting up a basic design-cost group has worked very successfully[2]. Because of pressure for output, need for concentrating on creative design, and the increasingly critical time span on engineering projects, the time necessary to devote to adequate cost studies and investigations is just not available. However, thorough design evaluations are a "must" for results and the responsibility therefore is assigned to the special design-cost group. Such a group functions in a consulting capacity, can devote full time to these activities and operate in an unbiased manner.

Generally, a design-cost group collaborates with the design and development sections of engineering which report direct to the chief engineer. Its proposals being in report form, are of course subject to final approval of the chief engineer. In order to assure proper dollars-and-cents results, however, cooperation between top management, engineering and manufacturing is imperative to permit the group to move freely throughout the entire organization in developing the required detailed data.

Size of the design-cost group will depend upon the effectiveness desired by management. Generally, a group ranging in size from one to five per cent of the design personnel involved has been found adequate. High-grade personnel, capable of independent operation and smooth interdepartmental functioning, are best qualified for this work and result in maximum cost benefit. Men well versed in manufacturing processes, cost accounting, production design techniques and industrial engineering standard data are required.

Duties of the design-cost group are twofold. One unit of the group covers project design, providing on-the-spot design-cost information. The second unit covers development, and works up basic design-cost data, standards on design for production, dollar cost factors, and analyses. The second unit collaborates with the first in the preparation of detailed comparative cost analyses to minimize detail duties and allow sufficient freedom for contacts with the design personnel.

PRODUCTION-DESIGN CONSULTANT: In small or moderate-size engineering departments, a method for coping with the problem of production design has evolved around the use of a production-design consultant. In some heavy machinery and special machine organizations, a well-trained process consultant is established as a resident member of the engineering department. Responsible to the production manager, this consultant brings into the design picture the practical aspects of production, tooling, labor, and sales.

To co-ordinate design and manufacture, the consultant prepares at the inception of a design a preliminary draft of manufacturing instructions which can be followed later in routing and rate setting. Costs can be forecast and from such information sup-

[1] References are tabulated at the end of this article for the purpose of further study concerning related phases of key importance.

Photo, courtesy Reed Rolled Thread Die Co.

Fig. 3—Redesign of cylinder head studs and connecting rod bolts for diesel locomotives to employ thread rolling resulted in over 50 per cent reduction in cost of the studs and 67 per cent for the bolts

port for authority to make extended design investigations into more economical methods is obtained. Constant surveillance by these means makes it possible to avoid any factors tending to direct a design into more costly channels. In addition, the usual train of design changes to suit manufacturing facilities which are reflected in expensive tooling changes and hidden costs are eliminated.

A simple example of the importance of minute detail work in production design can be seen from the drawings in *Fig.* 3. This small design modification, seemingly unimportant from any viewpoint, produced substantial cost reductions. Similar instances in small-lot quantity, heavy parts production can be found in untold numbers.

COMMITTEE PLAN: Considered by many as the most democratic and effective method of designing in a moderate to large-size organization, the development committee plan[3] has many merits. Based on the concept that designs and recommendations are more acceptable to members who participate in their formulation, the committee is composed of representatives from all departments affected by the decisions and policies made. Departments represented generally are: (1) Engineering, (2) tooling design, (3) production planning and scheduling, (4) manufacturing, (5) inspection, (6) service, (7) purchasing, and (8) sales.

Depending upon the particular product or products of the organization, chairmanship of the committee may vary[4]. Generally, a chairman from engineering is indicated since it is there that the whole crux of the situation lies. Technical background is usually an asset to the chairmanship and is desirable along with ability as a leader and enthusiasm for the job. In some companies, however, because of the great importance of the sales aspect and tremendous influence

Photo, courtesy Whiting Corp.

Fig. 4—Tremendous advantage is offered where designers are ever-conscious of production techniques available and are alert to cost saving practices

of the purchaser, as in appliances or office equipment, chairmanship by a member of the sales department has been found desirable. Other organizations have the committee headed by the product manager.

Planned procedure for such a committee is imperative and regular meetings are necessary along with good but not excessive records and proper follow-up. Exact scope of the committee must be established to keep the operation successful and within practical bounds. All new designs or suggestions for redesign are brought before the committee members for approval or recommendations. Once passed, the common problems of engineering "errors" or changes and production difficulties are largely eliminated.

PRODUCTION-CONSCIOUS DESIGNERS: A system which promotes the individual and aids in developing the latent initiative and ingenuity of designers might be said, perhaps, to offer the most advantage in seeking low-cost production design, *Fig.* 4. Thus, the development of alert, production-conscious designers can achieve the maximum benefit with minimum costs in organization, management, and equipment. One of the problems, of course, in instituting any formal system is that of gaining the intimate relationship necessary to draw out the best creative and imaginative efforts of each engineer. Unless the real feeling of belonging and participating in the work of the organization is developed, most systems may attain only superficial results.

Following this general concept, some concerns have successfully developed production-conscious designers[5]. This system is fully effective not only in repetitive production but also in special machinery and nonrepetitive fields where production-design aspects must be carried along concurrently with normal design. Production-design experts, cost, tooling, manufacturing, and other personnel are available or on-call for advice, cost analyses, etc. By this method the design engineers carry full responsibility and the problems of split-accountability are minimized. Too,

it also permits the shortest period of time between the idea and the shop.

To make this system fully effective in some companies in repetitive production, a goal for cost reduction is set for each year, say ten per cent. With a profit-sharing plan based on cost reductions, many erstwhile unbelievable goals have been made[6]. Needless to say, it has been established that any design can be improved and the cost in man-hours and materials reduced by proper design.

Production-Design Training: Good machine designers can be educated in this philosophy of design with the ultimate result that parts leave the board already production-modified or specified and detailed fairly well suited to low-cost production. Engineering management can institute continuous courses or sessions to condition designers' thinking in this direction and broaden their understanding of design producibility. Many interesting supplementary helps can be employed to drive home the general purpose. Aids such as charts and tabular data are extremely effective. Numerous case histories also serve to point up the problem.

Because the various fine points of design for specific manufacturing processes are too numerous to remember, some form of reference material[7] is indispensable. The mere fact that thorough understanding of the common manufacturing methods and an all-inclusive study of the possibilities requires consideration of some 54 methods attests to the need for specific reference data. Variations and process offshoots add to the possibilities but demand further study and familiarization. In addition, specific company standards and practices, correlated with National Standards[8], should be developed in reference manual form[9].

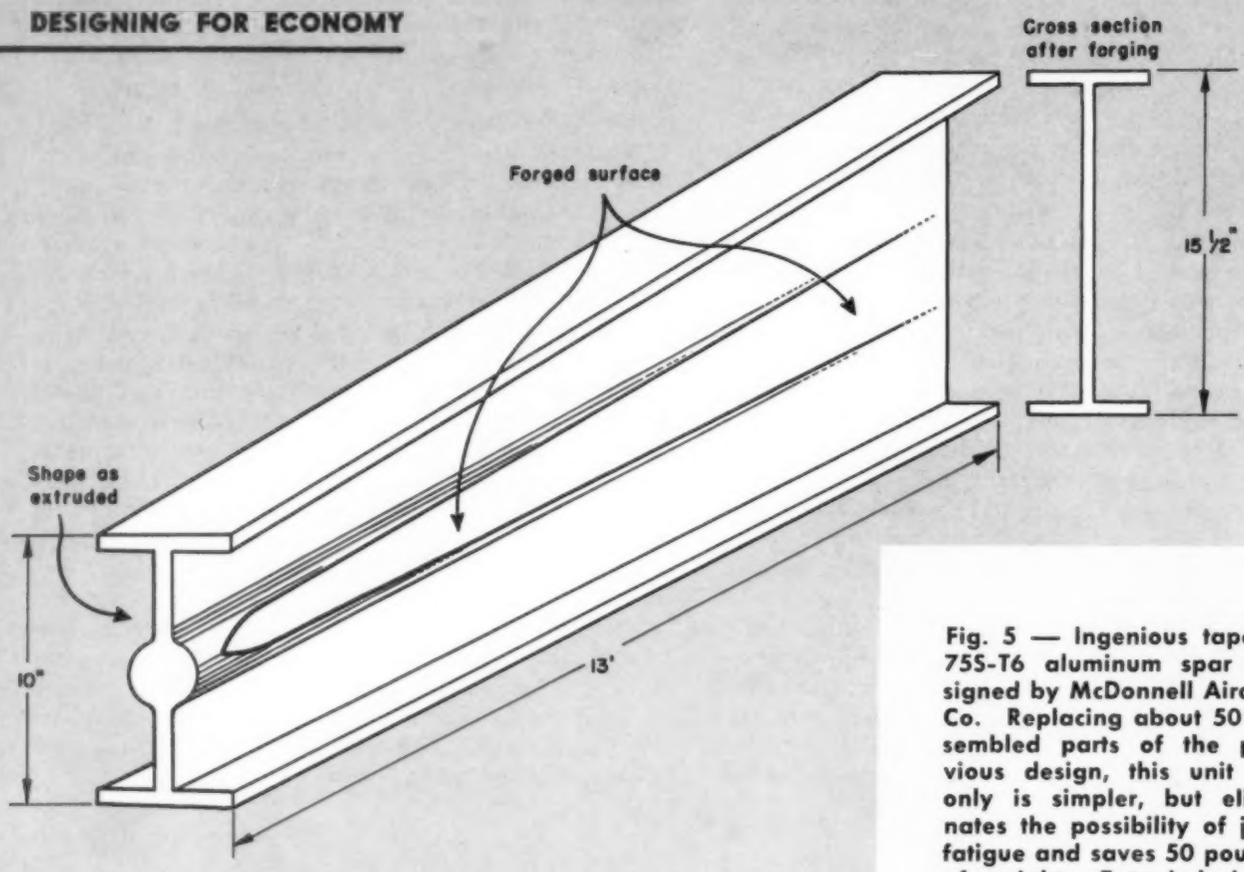
Design Personnel: Occasionally it is asked whether it would be preferable to seek men from the shop rather than to train engineers. Although a shop background is highly desirable, a sound engineering-design background is preferable. Aptitude plus engineering education cannot easily be supplanted by mere training. However, understanding of the practical aspects of manufacture can be readily attained by good designers. Once the general idea and purpose of such a program is genuinely presented to designers, their wholehearted support and enthusiasm can be anticipated. The necessary design interpretation of manufacturing limitations and advantages thus gained can be expected to produce results not possible or even dreamed of under the older systems. Once it becomes clear that a design incapable of economical production falls into the same category of importance as one incapable of proper functioning, the real significance and value of production design study will be outstandingly apparent. The results may be more important in the years to come than they have been in the past. Engineering management has a job to do and time is of the essence.

DESIGNING FOR ECONOMY

ON THE SURFACE of things, designs soundly engineered for manufacture may appear to be more expensive initially than those processed through in the usual manner. However, in the final analysis or upon thorough investigation the actual and hidden savings in labor and materials become apparent. The ultimate in value gained lies in the end result where not only lower costs and more expeditious production are gained but also in an improved product with better functional characteristics, Fig. 5.

Granting the decision is made that a program to insure manufacturing economy should be instituted, what is the general concept or design approach? What major design factors constitute the overall considerations? In the interests of promoting a thoroughgoing study and comprehension of the numerous facets comprising the general answers to these questions, this article will attempt to set up a series of basic rules for design.

Basic Concepts: Although it is possible to produce almost any design conceived, it does not necessarily follow that production costs will be reasonable or acceptable. The fact is that in only rare and exceptional cases are production costs of little or no consequence. The major proportion of all design requires a degree of practicability—the ultimate in simplified manufacture, minimum labor expenditure, lowest level of skills necessary, and minimum quantity and quality of materials is seldom attained. In the final analysis, therefore, it is axiomatic that design should be planned largely to suit basic operations available through the common manufacturing methods which can be tooled and adapted with the minimum effort. De-



Drawing, courtesy Aluminum Co. of America

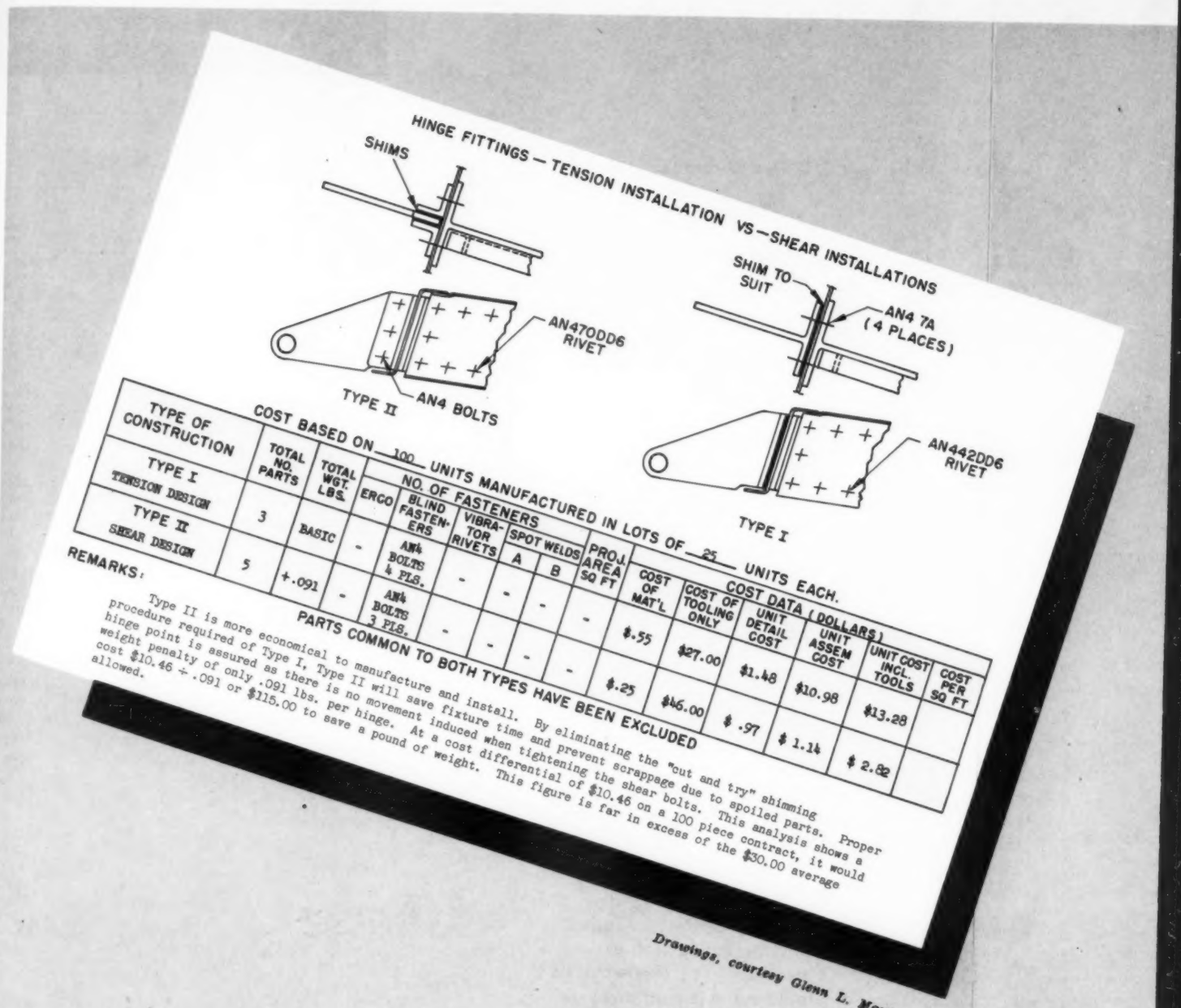
Fig. 5 — Ingenious tapered 75S-T6 aluminum spar designed by McDonnell Aircraft Co. Replacing about 50 assembled parts of the previous design, this unit not only is simpler, but eliminates the possibility of joint fatigue and saves 50 pounds of weight. Extruded shape is forge-tapered and the remaining bulb machined off

sign which centers only around the product and its function generally results in the necessity for special production facilities which seldom can be justified costwise except where quantity is considerable. Owing to the fact that few machines reach a production quantity sufficiently great to permit entirely special single-purpose production facilities, the practical aspects of design for manufacture are readily apparent.

Fields of Applicability: All too often the idea is voiced that design for production encompasses only the fields where at least a fair quantity of units are manufactured. Actually, the principles of good design for production apply equally to all fields regardless of quantities, *Fig.* 6. The telling factor in overall cost savings is found rather in the total of labor hours, tooling and materials saved over a specified period of time.

The area in which to place the major effort in design can be judged from a typical cost distribution based on quantity. As Wheelon[10] has shown, a cost percentage distribution according to (1) raw materials and purchased parts, (2) direct and indirect labor, and (3) engineering, tooling and administrative costs provides at a glance the relative importance of each of these factors in any area, *Fig.* 7. For small quantities, manufacturing labor, tooling and engineering are key factors. Design must employ to the maximum degree possible stock or standard parts and producibility must be inherent when parts leave the board. As quantities reach the 10,000-unit level the order changes; raw materials and purchased parts replace engineering, tooling and administration while manufacturing labor retains its importance. Here, the opportunities for comprehensive design-cost control programs are great; extensive engineering for producibility results in only a minor expenditure prorated over the quantities produced but savings can be tremendous.

Rules for Design: To assure sound design from a producibility standpoint requires consideration of the following general rules both separately and in combination. The order of importance may vary according to design requirements, quantities, or other factors but the overall importance always remains the same.



COST BASED ON 100 UNITS MANUFACTURED IN LOTS OF 25 UNITS EACH.

TYPE OF CONSTRUCTION	TOTAL NO. PARTS	TOTAL WGT. LBS.	NO. OF FASTENERS: ERCO	BLIND FASTENERS	VIBRATOR RIVETS	SPOT WELDS: A	SPOT WELDS: B	PROJ AREA SQ FT	COST DATA (DOLLARS): COST OF MAT'L	COST OF TOOLING ONLY	UNIT DETAIL COST	UNIT ASSEM COST	UNIT COST INCL. TOOLS	COST PER SQ FT
TYPE I TENSION DESIGN	3	BASIC	-	AN4 BOLTS 4 FLS.	-	-	-	-	$.55	$27.00	$1.48	$10.98	$13.28	
TYPE II SHEAR DESIGN	5	+.091	-	AN4 BOLTS 3 FLS.	-	-	-	-	$.25	$46.00	$ .97	$ 1.14	$ 2.82	

PARTS COMMON TO BOTH TYPES HAVE BEEN EXCLUDED

REMARKS:

Type II is more economical to manufacture and install. By eliminating the "cut and try" shimming procedure required of Type I, Type II will save fixture time and prevent scrappage due to spoiled parts. Proper hinge point is assured as there is no movement induced when tightening the shear bolts. This analysis shows a weight penalty of only .091 lbs. per hinge. At a cost differential of $10.46 on a 100 piece contract, it would cost $10.46 ÷ .091 or $115.00 to save a pound of weight. This figure is far in excess of the $30.00 average allowed.

Drawings, courtesy Glenn L. Martin Co.

Fig. 6—Design-cost analysis for an aircraft hinge fitting. Quantities are small but cost factor variation can be tremendous

RULE 1. *Seek simplicity. Design for maximum simplicity of all functional and physical characteristics.* Although it could be said that this factor is rather self-evident, it is continually overlooked or ignored and requires emphasis. Actually, achievement of maximum simplicity is often a great deal more difficult than not. But because production cost has a direct relation to the complexity of design, efforts toward simplifying both parts and assemblies can result in real savings, *Fig.* 8.

It has been exemplified many times that where design configuration can be simple and uncomplicated, load-carrying capacity is generally more certain and service life is extended. Because the determination of stresses within a complex structure is extremely difficult and actual stress distribution is often obscure, the value of simplicity at once becomes apparent.

In the interests of simplicity, several questioning approaches should be considered. These can be enumerated as:

TABLE 1—MACHINABILITY

CLASS 1. Ferrous (70% and higher)

No. AISI	Rating (per cent)	Hardness (Brinell)
C 1109	85	137 to 166
C 1115	85	143 to 179
C 1117	85	143 to 179
C 1118	80	143 to 179
C 1120	80	143 to 179
C 1132	75	187 to 229
C 1137	70	187 to 229
C 1022	70	159 to 192
C 1016	70	137 to 174
B 1111	95	179 to 229
B 1112	100	179 to 229
B 1113	135	179 to 229
A 4023	70	156 to 207
A 4027*	70	166 to 212
Malleable iron, standard	120	110 to 145
Malleable iron, pearlitic	90	180 to 200
Malleable iron, pearlitic	80	200 to 240
Cast steel (0.35% C)	70	170 to 212
Stainless iron, 12% Cr (free cutting)	70	163 to 207

* Steel in mill-annealed condition

CLASS 2. Ferrous (50% to 60%)

No. AISI	Rating (per cent)	Hardness (Brinell)
C 1141	65	183 to 241
C 1020	65	137 to 174
C 1030	65	170 to 212
C 1035	65	174 to 217
C 1040*	60	179 to 229
C 1045*	60	179 to 229
A 2317	55	174 to 217
A 3120	60	163 to 207
A 3130*	55	179 to 217
A 3140*	55	187 to 229
A 3145*	50	187 to 235
A 4032*	65	170 to 229
A 4037*	65	179 to 229
A 4042*	60	183 to 235
A 4047*	55	183 to 235
A 4130*	65	187 to 229
A 4137*	60	187 to 229
A 4145*	55	187 to 229
A 4150*	50	187 to 235
A 4320	55	197 to 228
A 4615	65	174 to 217
A 4640*	55	187 to 235
A 4815	50	187 to 229
A 5120	65	170 to 212
A 5140*	60	174 to 229
A 5150*	55	179 to 235
A 8620 or 8720	60	170 to 217
A 8630* or 8730*	65	179 to 229
A 8640* or 8740*	60	179 to 229
A 8645* or 8745	55	183 to 235
A 8650* or 8750*	50	183 to 241
A 9420	60	170 to 217
A 9440*	60	187 to 235
Cast iron, soft	80	160 to 193
Cast iron, medium	65	193 to 220
Cast iron, hard	50	220 to 340

* Steel in mill-annealed condition

1. Is the part absolutely required?
2. Can the part be eliminated?
3. Can two or more assembled parts be combined?
4. Can a complex part be divided into two or more much more simpler parts?
5. Can a standard part be employed?

The most obvious savings can be made by eliminating or combining parts to obviate production and assembly costs. However, the somewhat less obvious possibility of dividing a complicated piece into several simpler parts, more economical to manufacture and assemble, should not be overlooked in the process, *Fig.* 9. The value of using standard parts rather than special ones, regardless of whether they are company standardized or vendor standards, can be easily demonstrated in innumerable instances by cost analyses, *Fig.* 9.

The factor of simplicity also assumes importance in the assembly stage. Fast, satisfactory assembly at minimum expense in labor hours is imperative. Lowest cost *standard* fasteners of the most effective design and in the smallest possible number should be the aim. Machines or mechanisms which are difficult to assemble not only incur excessive production costs, *Fig.* 10, but also generally result in considerably increased maintenance or servicing difficulty and, as a consequence, receive poor customer acceptance.

RULE 2. *Determine the best production method. Design for the most economical production method or methods available and observe their inherent design limitations.*

Without serious consideration of alternate designs and comparative analyses, the chance of achieving the ideal state of producibility in any instance is rather debatable. The tendency to hold to a few well-known methods is all too easy and it becomes mandatory to think in terms of comparable designs producible by different techniques.

In addition, the important factor of quantity must be kept in mind[2]. It must be recognized that every production method has a rather specific quantity range outside which cost becomes excessive in comparison with other methods of achieving similar results.

Thus, the general design characteristics and quantity requirements of specific parts usually can be expected to place them in a well-defined production category. And, vice versa, parts of similar function designed for manufacture by different methods will, with identical production quantities, fall into differing cost categories[11]. Little real competition or overlapping of production methods exists actually. Some valid factor such as tooling cost, quantity, handling capacity, process limitations, or the like will normally rule out most possible alternates along with

ATINGS OF METALS AND PROCESSES§

CLASS 3. Ferrous (40% to 50%)

No. AISI	Rating (per cent)	Hardness (Brinell)
C 1008	50	126 to 163
C 1010	50	131 to 170
C 1015	50	131 to 170
C 1050*	50	179 to 229
C 1070*	45	183 to 241
A 1320	50	170 to 229
A 1330*	50	179 to 235
A 1335*	50	187 to 241
A 1340*	45	187 to 241
A 2330*	50	179 to 229
A 2340*	45	187 to 241
A 3240*	45	187 to 241
A 4340*	45	187 to 241
NE 9261*	50	179 to 217
A 6120	50	179 to 217
A 6145*	50	179 to 235
A 6150†	45	183 to 241
A 9260*	45	187 to 255
Ingot iron	50	101 to 131
Wrought iron	50	101 to 131
Stainless 18-8 (Free cutting)	45	179 to 212

* Steel in mill-annealed condition. †Spheroidized.

CLASS 4. Ferrous (40% and less)

No. AISI	Rating (per cent)	Hardness (Brinell)
A 2515*	30	170 to 229
E 3310*	40	170 to 229
E 52100†	30	183 to 229
E 9315	40	170 to 229
Ni-Resist*	30	.....
Stainless 18-8 (austenitic)*	25	150 to 160
Manganese oil-hardening steel†	30	.....
Tool steel, low-tungsten, chromium and carbon†	30	.....
High speed steel†	30	200 to 218
High-carbon, high-chromium tool steel†	25	.....

* Steel in mill-annealed condition. † Spheroidized
§ From *Metals Handbook*, American Society for Metals. Metals rated to nearest 5 per cent based on 100 per cent rating for B1112 cold rolled or cold drawn, when machined with a suitable cutting fluid at 180 fpm under normal conditions using high-speed steel tools.

CLASS 5. Non Ferrous (more than 100%)

Alloy	Rating (per cent)	Hardness (Brinell)
Magnesium alloys		
Wrought (92.3 Mg, 6.5 Al, 0.2 Mn, 1.0 Zn)	500 to 2000	58
Cast (90.8 Mg, 6 Al, 0.2 Mn, 3.0 Zn)	500 to 2000	50
Aluminum		
11 S-T3 (5.5 Cu, 0.5 Pb, 0.5 Bi, 93.5 Al)	500 to 2000	.....
2 S (100 Al) 0 to H temper	300 to 1500	95(500 kg)
17 S-T (4 Cu, 0.5 Mn, 0.5 Mg, 95.0 Al)	300 to 1500	23 to 44(500 kg)
Brass, leaded FC, CD (62 Cu, 35 Zn, 3.0 Pb)	200 to 400	100(500 kg)
Red, leaded (78.5 Cu, 20 Zn, 1.5 Pb)	180	40 to 75*
Phosphor bronze, leaded (94 Cu, 1.0 Pb, 5.0 Sn)	100	60 to 100*
Zinc	200	.....
Silicon bronze (95.60 Cu, 1.0 Mn, 3.0 Si, 0.4 Pb)	120	200

* Rockwell B hardness readings.

CLASS 6. Non Ferrous (less than 100%)

Alloy	Rating (per cent)	Hardness (Brinell)
Aluminum bronze, cast (89.7 Cu, 10 Al, 0.2 Fe, 0.5 Sn)	60	140 to 160
Brass		
Yellow (63 Cu, 37 Zn)	80	.....
Red (80 Cu, 20 Zn)	60	40 to 75*
Manganese bronze (59 Cu, 39 Zn, 0.7 Sn, 0.5 Mn, 0.8 Fe)	60	.....
Phosphor bronze (95 Cu, 5 Sn)	40	140
Copper cast	70	30
Copper, rolled (¼ hard)	60	80
Silicon bronze (95.80 Cu, 1.10 Mn, 3.10 Si)	60	200
Gun metal, cast (88 Cu, 10 Sn, 2 Zn)	60	65
Nickel	55	110 to 150
Monel metal		
As Cast	40	175 to 250
Rolled	55	207 to 224
"K" Monel	35	215 to 265
Inconel, temper B, cold drawn (78 Ni, 14 Cr, 6 Fe)	35	130 to 170

* Rockwell B hardness reading.

RELATIVE SEVERITY OF MACHINING*

Process	Rating
Broaching; internal	1
Broaching; surface	2
Tapping; plain	3
Threading; pipe	2
Threading; plain	3
Gear shaving	4
Reaming; plain	4
Gear cutting	4
Drilling; deep	5
Milling; plain	6
Milling; multiple cutter	6
Boring; multiple head	7
Multiple-spindle automatics	7
High-speed, light-feed automatics	8
Drilling	9
Planing, shaping	9
Turning; single-point, form	9
Sawing; circular, hack	10
Grinding; plain, form	10

* Ratings range from 1, the most severe, to 10, the least severe operation, on a general comparative basis assuming normal average conditions throughout. Importance of machinability increases with severity.

such imperatives as materials, strength, finish, etc.

Tool-up cost of a process is an important factor to consider along with quantity, *Fig.* 11. As quantities increase, greater and greater tool-up costs can be absorbed without affecting part cost appreciably. The fact must be observed, however, that here again judgment must be tempered with figures to assure economical results. High tool-up costs can be and often are exceeded by high production costs on complex parts requiring considerable special handling[11].

Economy dictates avoidance of untried or experimental processes except in unusual instances. The best procedure is to design for standard available processes, with special consideration for those methods at hand in the shop, but not to the exclusion of processes available from specialists at lower costs.

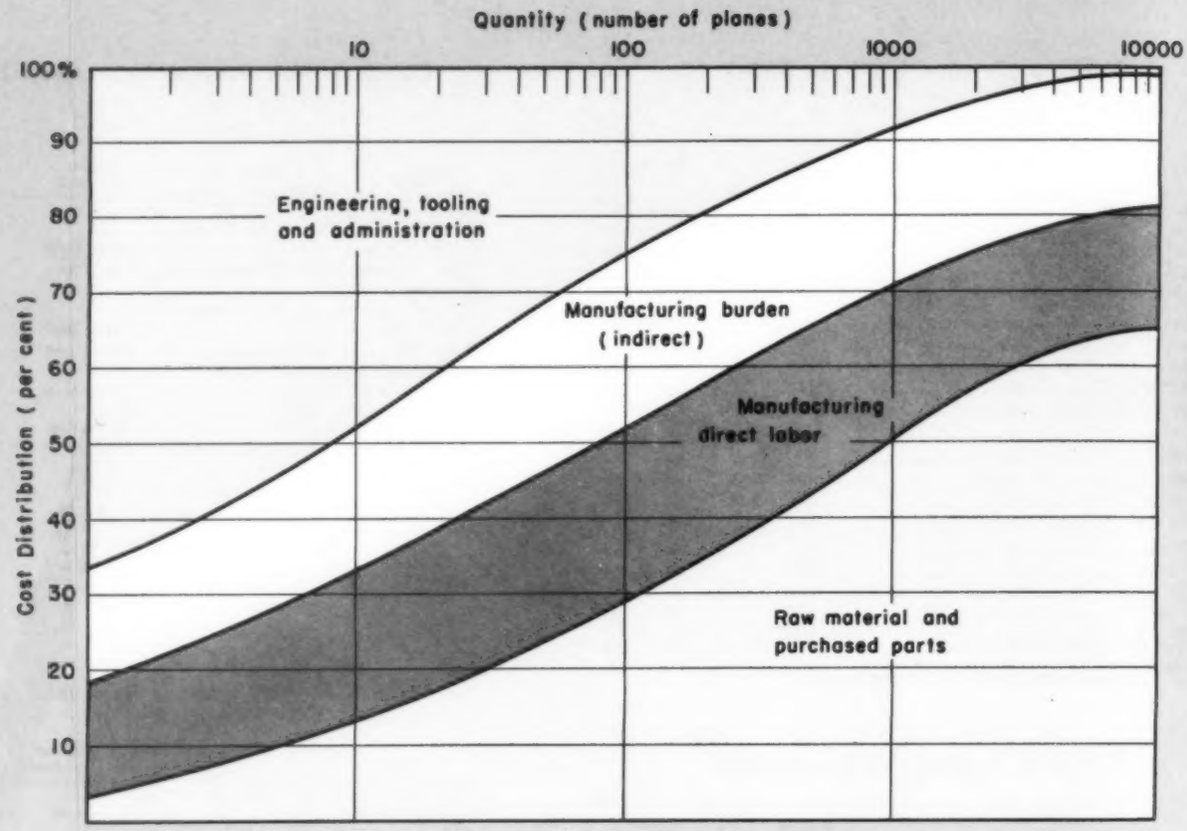


Fig. 7—Cost distribution factors charted in relation to quantity to indicate changing emphasis as production increases

However, in any design instance, the use of or demand for the exceptional capabilities of any particular process should be minimized to the greatest extent possible.

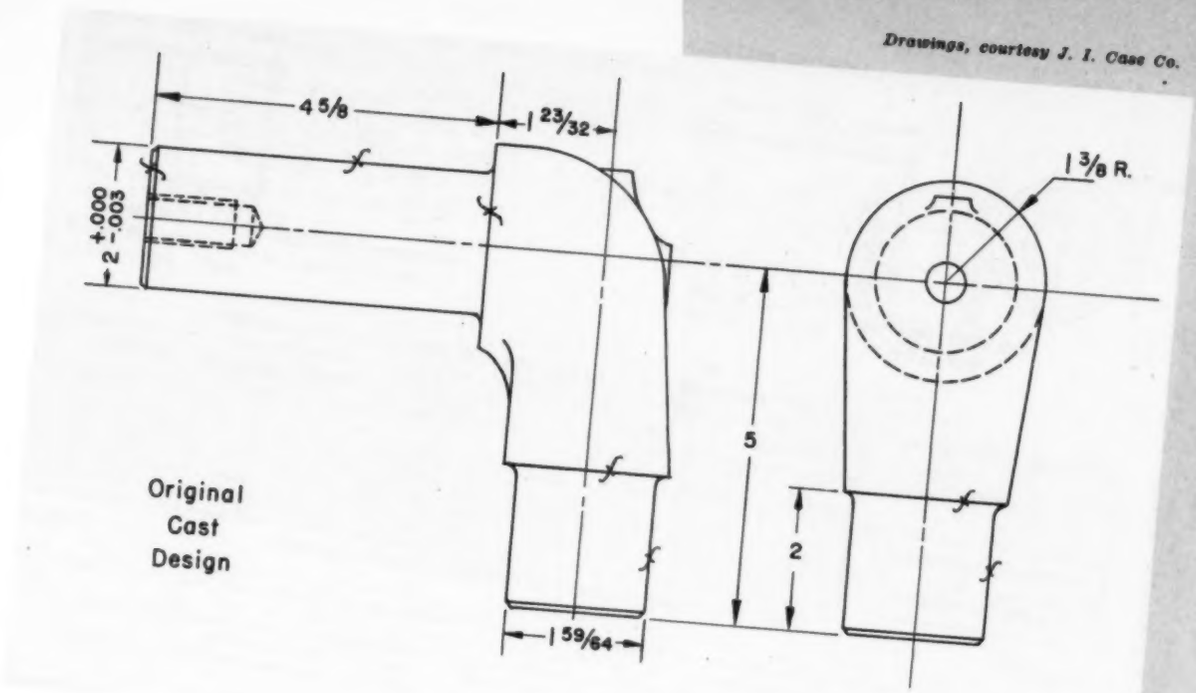
RULE 3. *Analyze specified material or materials carefully. Select materials to suit the production method as well as the design requirements.*

Selection of materials can play a key role in the achievement of low costs. The designer can specify a forged part costing $1.00 per pound or an alternate perhaps of formed sheet steel at $0.10 per pound. Manufacturing time required, however may be important. Machinability, workability, castability, moldability, formability, and weldability of materials vary widely and no one material is ideal. Some small compromise in many cases can result in drastic cost reductions. For instance, although aluminum and magnesium alloys cost more than steel or steel alloys for similar designs, the time required for machining the lightweight alloys may be sufficiently less to offset by far the difference in raw material cost, *Fig.* 12. Comparative machinability ratings, TABLE 1, of various materials permits a fair judgment as to their ease of machining in general. With steels a special structure sometimes may be desirable for specific machining operations and this usually requires a suitable heat treatment. Likewise, with cold-forming operations, a suitable structure may be desirable, regardless of the type of metal to be worked.

The same considerations can be applied to other materials. For instance, moldability of materials can be of importance in final production costs, *Fig.* 13. Adaptability to the method best suited to processing must be rated as parallel in importance with suitability for the application if reasonable costs are to be achieved.

Where critical parts are being designed, the effects of the processing on the ultimate material quality should be considered. Stringent requirements regarding soundness of material may result in excessive inspection costs and rejections with special parts, *Fig.* 14. With the trunion bracket in *Fig.* 10, tools for forging, costing approximately $50,000,

Drawings, courtesy J. I. Case Co.



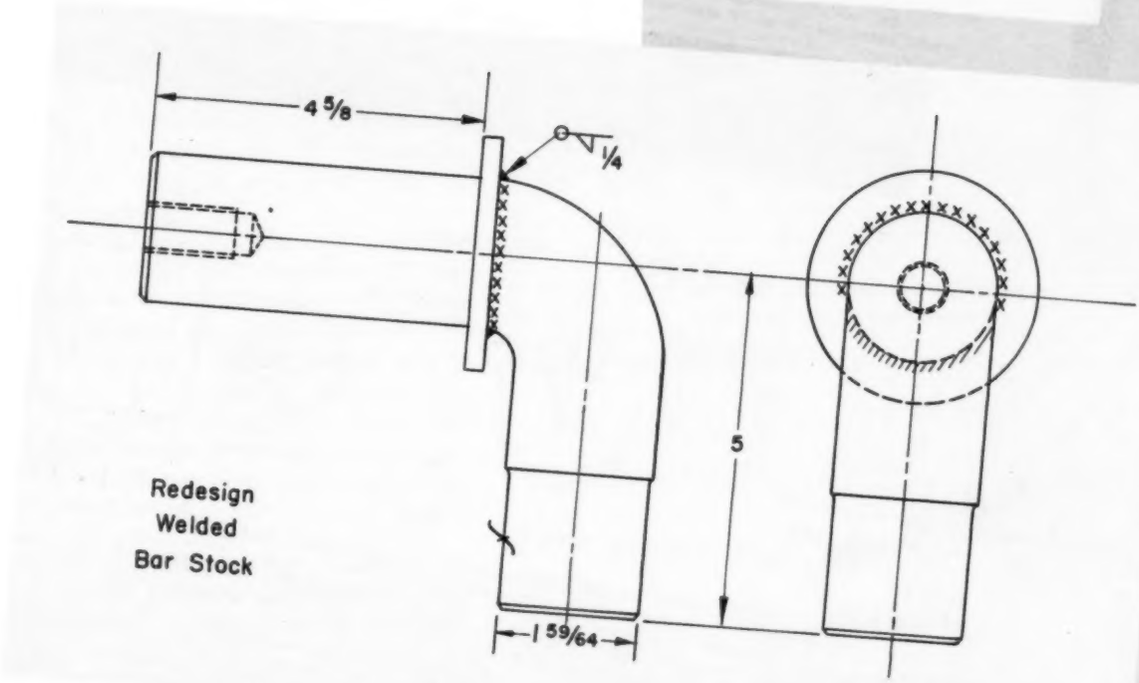
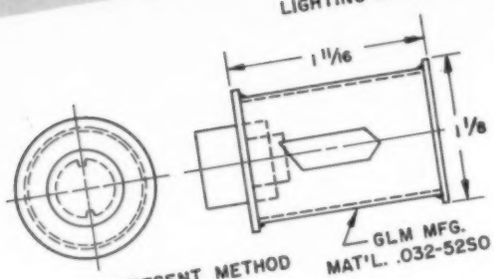
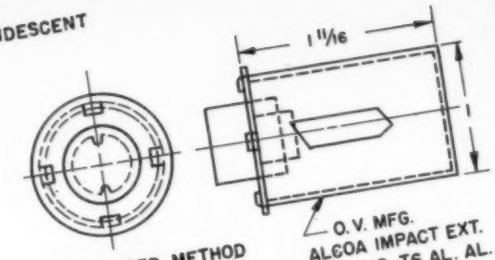


Fig. 8—Steel bracket casting redesigned to be manufactured from two C-1020 steel parts and welded. This redesign resulted in a saving of approximately $2.18 per assembly and $4.36 per machine employing two units each

LIGHTING INSTALLATION - AUX. INCANDESCENT





COSTS BASED ON ONE PRODUCTION LOT FOR QUANTITIES SHOWN

TYPE	LABOR		UNIT MAT'L. COST	UNIT COST INCLUDING LABOR AND MATERIAL						
	S/U HOURS	R/T HOURS		1	10	25	50	100	200	500
WELDED TUBE ASSEMBLY	1.33	.321	.026	16.33	3.80	2.94	2.59	2.37	2.32	2.30
CRIMPED CAN ASSEMBLY	1.06	.173	.021	12.19	2.34	1.70	1.46	1.31	1.27	1.25

PARTS COMMON TO BOTH TYPES HAVE BEEN EXCLUDED

REMARKS:

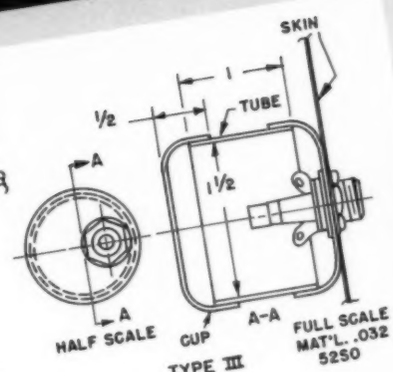
The crimped can assembly is the most economical for all quantities. This saving is achieved by the elimination of the welded ends.

A cost saving not shown in this analysis is the reduction in the number of parts from three to two, thus saving an additional shop folder every time the assembly is released for production.

The use of a standard ALCOA impact extrusion for adaption to a G.L.M. design, provides a substantial cost savings as shown by this analysis.

Fig. 9—Alternate design-cost analysis for an aircraft assembly reducing the number of parts and employing a standard unit

FUEL TANK GROUNDING JACK RECEPTACLE



COSTS BASED ON ONE PRODUCTION LOT FOR QUANTITIES SHOWN

TYPE	LABOR		UNIT MAT'L. COST	TOTAL TOOL COST	UNIT COST INCLUDING LABOR, MATERIAL AND TOOLS						
	S/U HOURS	R/T HOURS			1	10	25	50	100	200	500
I PLASTIC	1.34	.323	.19	134.97	$169.56	$19.49	$9.42	$5.89	$3.97	$3.24	$2.82
II SHEET METAL ASSEMBLY HYDRO-PRESS & SPINNING	2.03	.216	.25	118.48	154.39	16.67	7.76	4.73	3.13	2.46	2.07
III MARFORM ASSEMBLY	1.43	.084	.06	82.31	104.24	10.56	4.58	2.60	1.58	1.12	.85

PARTS COMMON TO ALL TYPES HAVE BEEN EXCLUDED (SKIN)

REMARKS:

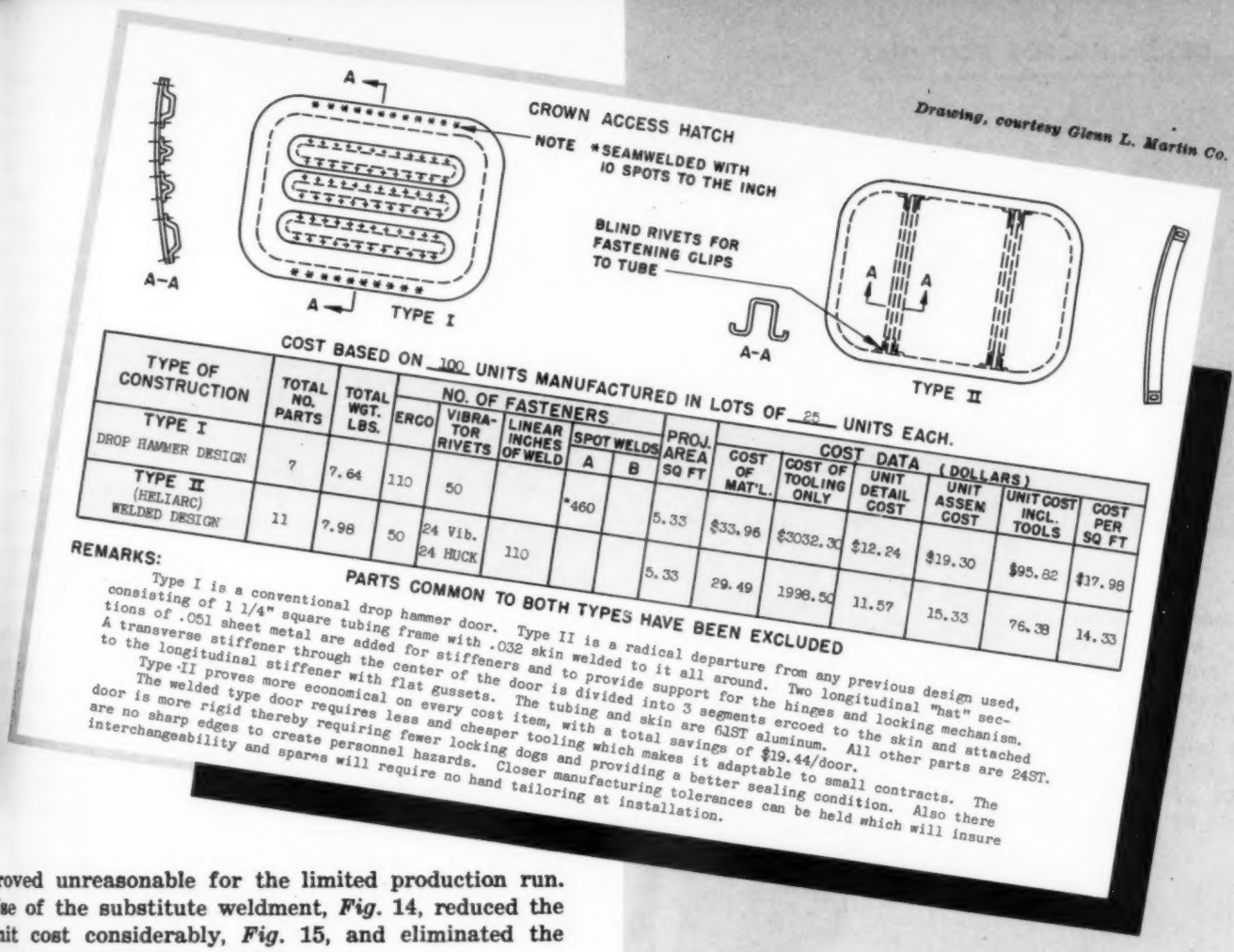
Type III is the most economical design for all quantities. This savings is the result of the use of a simple Marform tool for the cap and the absence of assembly attaching methods; such as, rivets, screws, or welding. The close tolerance fit between the I.D. of the cup and the O.D. commercial tolerances of the tube permits a satisfactory friction bond.

The relatively high cost for Type I is attributed to the slow hand assembly methods which does not readily lend itself to production techniques.

The principal reasons for the higher cost of Type II design is the riveted assembly cost and the high set-up and run-time cost of the spun cup.

Fig. 10—Design-cost analysis for an aircraft grounding jack receptacle. Cost of assembly is an outstanding factor in this instance

Drawings, courtesy Glenn L. Martin


CROWN ACCESS HATCH
Drawing, courtesy Glenn L. Martin Co.
NOTE *SEAMWELDED WITH 10 SPOTS TO THE INCH
BLIND RIVETS FOR FASTENING CLIPS TO TUBE
A-A
TYPE I
TYPE II
COST BASED ON 100 UNITS MANUFACTURED IN LOTS OF 25 UNITS EACH.
REMARKS:
PARTS COMMON TO BOTH TYPES HAVE BEEN EXCLUDED
Type I is a conventional drop hammer door. Type II is a radical departure from any previous design used, consisting of 1 1/4" square tubing frame with .032 skin welded to it all around. Two longitudinal "hat" sections of .051 sheet metal are added for stiffeners and to provide support for the hinges and locking mechanism. A transverse stiffener through the center of the door is divided into 3 segments ercoed to the skin and attached to the longitudinal stiffener with flat gussets. The tubing and skin are 61ST aluminum. All other parts are 24ST.
Type II proves more economical on every cost item, with a total savings of $19.44/door.
The welded type door requires less and cheaper tooling which makes it adaptable to small contracts. The door is more rigid thereby requiring fewer locking dogs and providing a better sealing condition. Also there are no sharp edges to create personnel hazards. Closer manufacturing tolerances can be held which will insure interchangeability and spares will require no hand tailoring at installation.

TYPE OF CONSTRUCTION	TOTAL NO. PARTS	TOTAL WGT. LBS.	NO. OF FASTENERS					PROJ. AREA SQ FT	COST DATA (DOLLARS)					
			ERCO	VIBRATOR RIVETS	LINEAR INCHES OF WELD	SPOT WELDS A	SPOT WELDS B		COST OF MAT'L.	COST OF TOOLING ONLY	UNIT DETAIL COST	UNIT ASSEM COST	UNIT COST INCL. TOOLS	COST PER SQ FT
TYPE I DROP HAMMER DESIGN	7	7.64	110	50		*460		5.33	$33.96	$3032.30	$12.24	$19.30	$95.82	$17.98
TYPE II (HELIARC) WELDED DESIGN	11	7.98	50	24 Vib. 24 HUCK	110			5.33	29.49	1998.50	11.57	15.33	76.38	14.33

Fig. 11 — Crown access hatch design-cost analyses in which the effect of tooling costs can be seen as a deciding factor along with design improvement

proved unreasonable for the limited production run. Use of the substitute weldment, *Fig.* 14, reduced the unit cost considerably, *Fig.* 15, and eliminated the previous failures experienced.

With working, casting, molding, forming, and welding operations the suitability of materials for economical processing must be considered in a like manner. However, where design requirements allow little or no leeway as to material selection, design will be influenced directly by the production methods suitable for completing a satisfactory part or parts. Because materials characteristics are so inextricably associated with economical processing, this phase of design cannot be overemphasized.

RULE 4. ***Minimize production steps. Design for the minimum number of separate operations in machining, finishing, forming, molding, casting, fabricating, or assembling.***

Every design produced with the aim of economy in mind must be scrutinized searchingly for needless production operations which can be eliminated. Naturally, the fewer the separate operations necessary, the lower will be the cost in production hours. Design details which often appear insignificant may contribute greatly to the cost, *Fig.* 16. Every process must be carefully appraised on the basis of small details because invariably the minor detail limitations of a process are the key factors in attaining satisfactory economy.

Here again, assembly can be important. As mentioned under RULE 1 on simplicity, ease of assembly is paramount whether original factory assembly or customer maintenance is concerned. Substantial savings can be effected at the same time improved performance is obtained, *Fig.* 17.

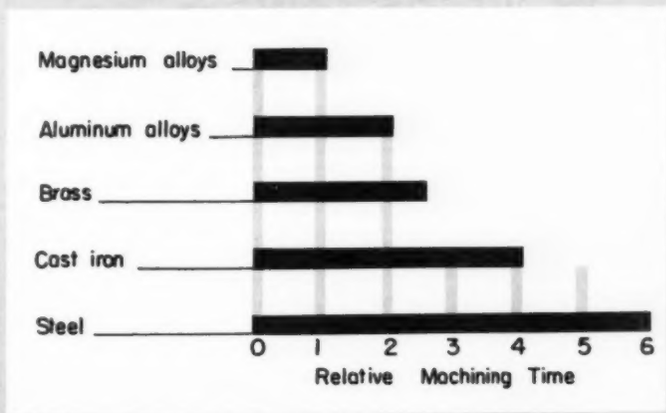
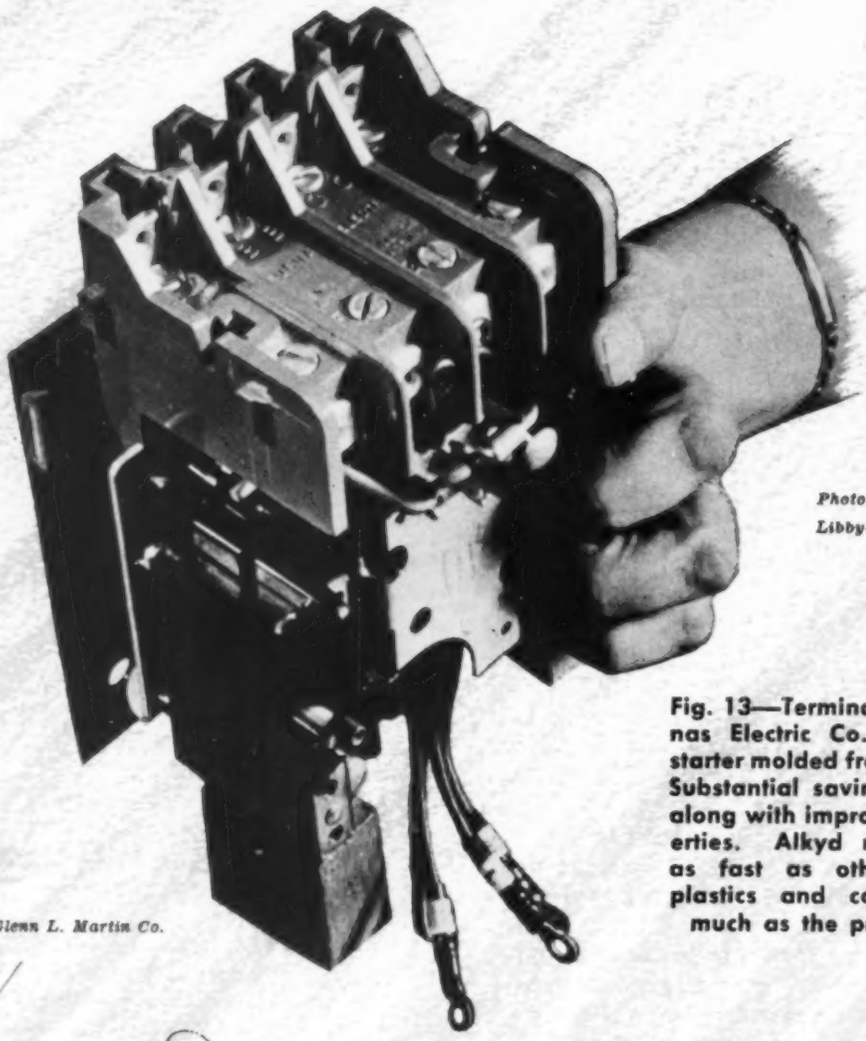


Fig. 12—Chart showing general comparative machining rates of various metals. The economy of machining the light metals is readily apparent



Photo, courtesy Plaskon Div., Libby-Owens-Ford Glass Co.

Fig. 13—Terminal block for a Furnas Electric Co. magnetic motor starter molded from Plaskon alkyd. Substantial savings were realized along with improved electric properties. Alkyd molds four times as fast as other thermosetting plastics and costs one-half as much as the previous material

Drawing, courtesy Glenn L. Martin Co.

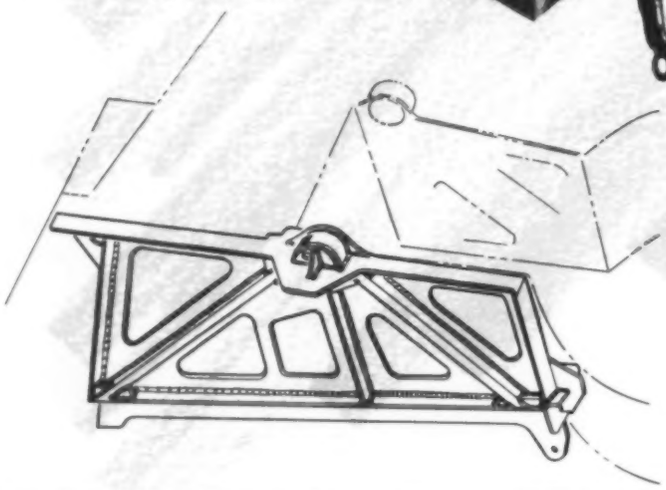


Fig. 14—Main gear trunnion fitting originally designed as a steel casting proved expensive for the limited production required and was finally redesigned for welding

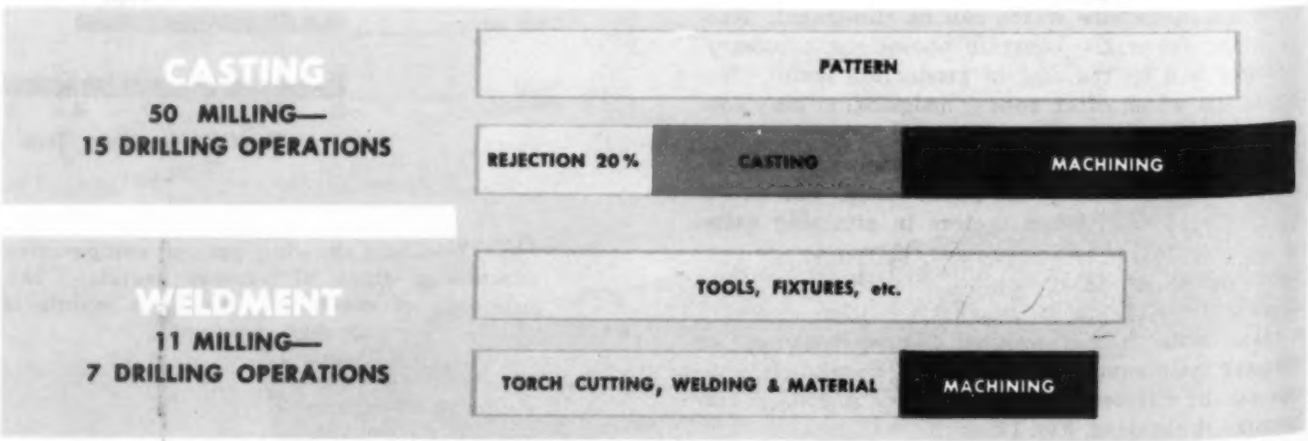


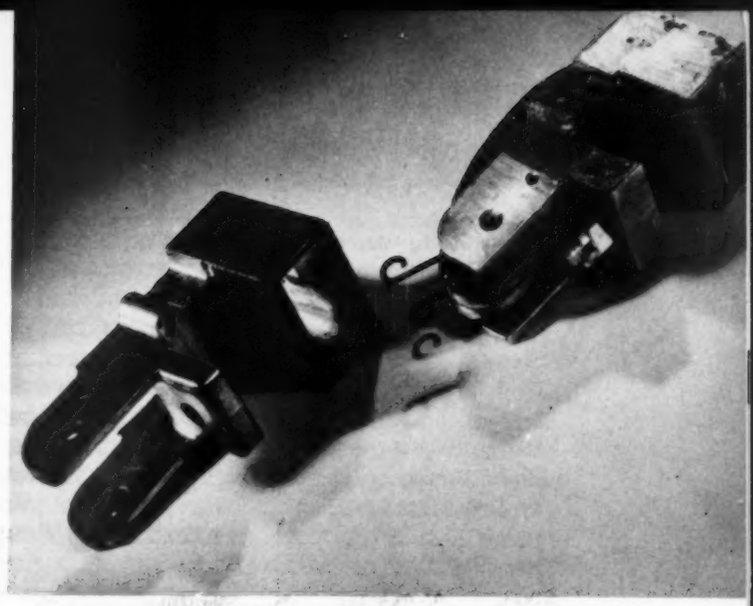
Fig. 15—Cost comparison of cast and welded designs for the trunnion shown in Fig. 14

RULE 5. *Eliminate handling problems. Design for ease of locating, setting up, holding, and handling parts.*

In the case of parts which must be held or located in jigs or fixtures during processing, consideration should be given the means by which such operations can be readily accomplished. Lugs may be added, contours changed, or sections varied to make handling a simple rather than a costly operation. A good understanding of the processing functions involved with each method as well as an appreciation of the various aspects of fixturizing, holding and feeding parts can achieve vastly improved production, lower tooling costs and, of course, lower part cost.

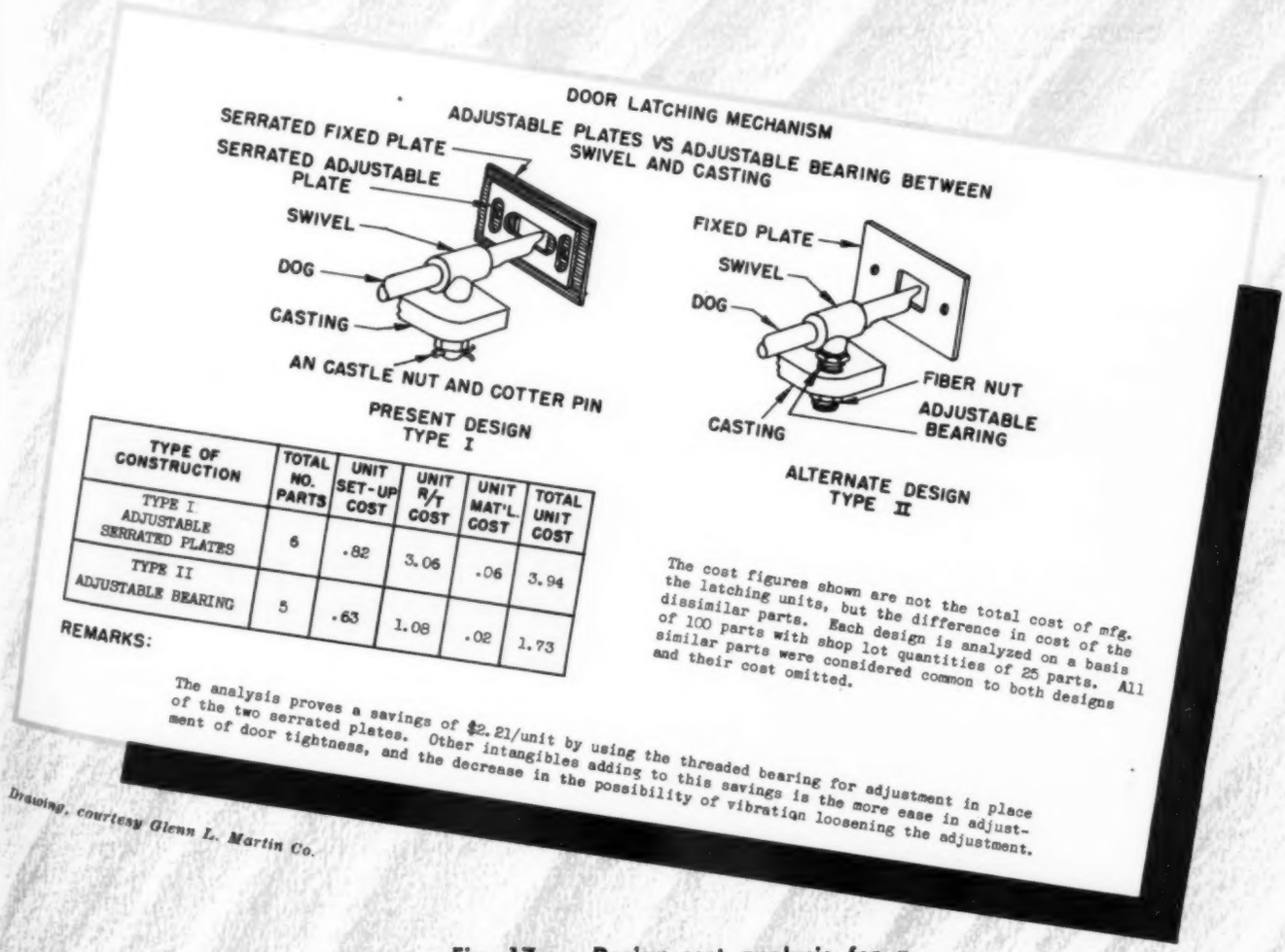
RULE 6. *Employ maximum acceptable tolerances and finishes. Specify surface roughness and accuracy no greater than that commensurate with the type of part or mechanism being designed and the production method or methods contemplated.*

Tolerances on finish and dimensions play an important part in the final achievement or absence of practical production design. A comprehensive study of the principles of interchangeable manufacture is essential for a thorough understanding and full ap-



Photo, courtesy Westinghouse Electric Corp.

Fig. 16—Reaction brush holder for d-c motors as originally designed for sand casting, right, and for permanent-mold casting, left. All milling, filing, fitting, and straightening were eliminated, drilling, tapping and burring requiring only 0.09-hour as against 0.97-hour previously. Total cost of $8.77 per assembly was reduced to $1.54, the casting itself being reduced from $1.06 to $0.48 and the brush fingers from $0.52 to $0.22



TYPE OF CONSTRUCTION	TOTAL NO. PARTS	UNIT SET-UP COST	UNIT R/T COST	UNIT MAT'L. COST	TOTAL UNIT COST
TYPE I ADJUSTABLE SERRATED PLATES	6	.82	3.06	.06	3.94
TYPE II ADJUSTABLE BEARING	5	.63	1.08	.02	1.73

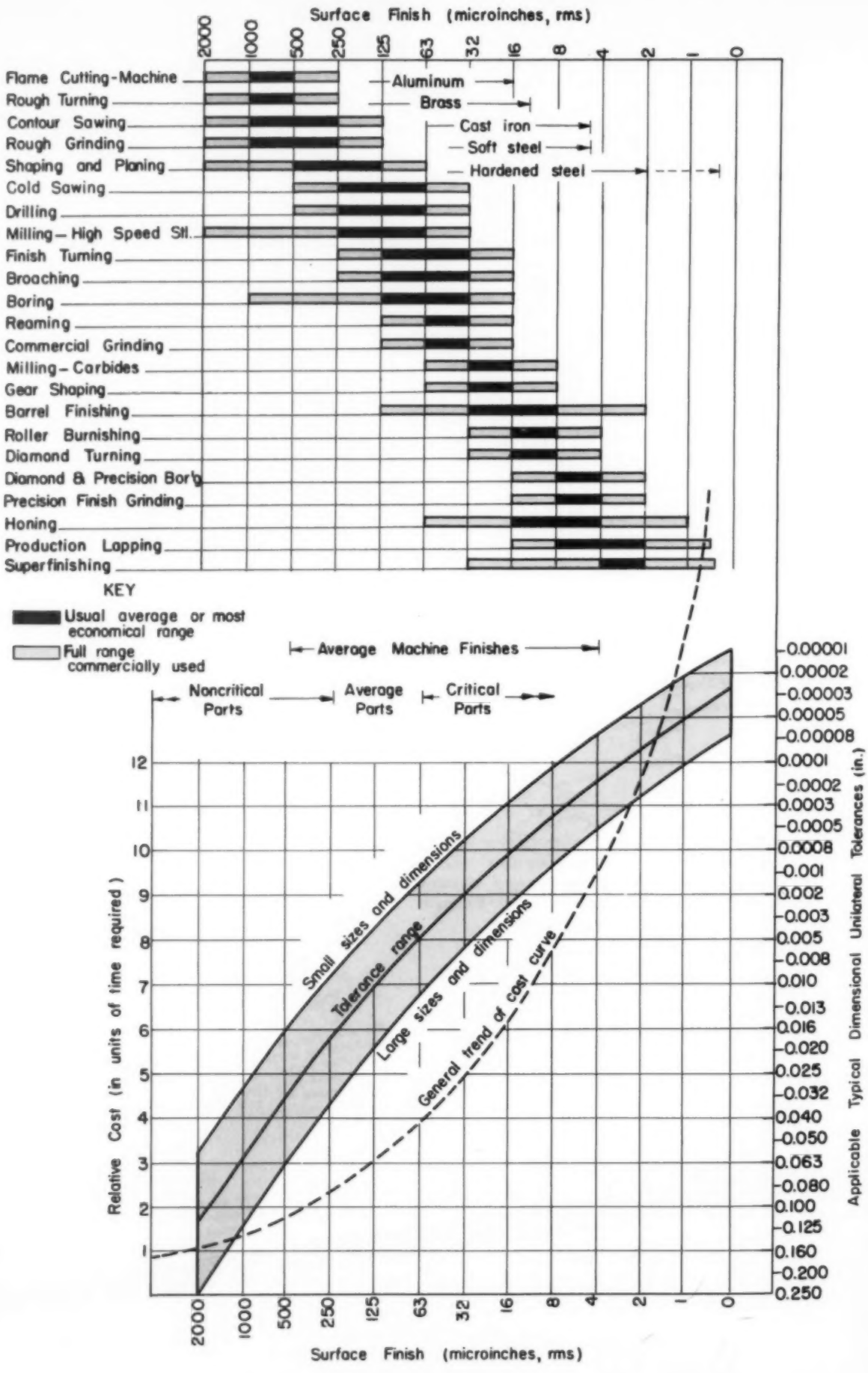
The cost figures shown are not the total cost of mfg. the latching units, but the difference in cost of the dissimilar parts. Each design is analyzed on a basis of 100 parts with shop lot quantities of 25 parts. All similar parts were considered common to both designs and their cost omitted.

REMARKS:

The analysis proves a savings of $2.21/unit by using the threaded bearing for adjustment in place of the two serrated plates. Other intangibles adding to this savings is the more ease in adjustment of door tightness, and the decrease in the possibility of vibration loosening the adjustment.

Drawing, courtesy Glenn L. Martin Co.

Fig. 17 — Design-cost analysis for a door latching mechanism. Savings were augmented by improved performance and maintenance


Surface Finish (microinches, rms)
2000
1000
500
250
125
63
32
16
8
4
2
1
0
Flame Cutting - Machine
Rough Turning
Contour Sawing
Rough Grinding
Shaping and Planing
Cold Sawing
Drilling
Milling – High Speed Stl.
Finish Turning
Broaching
Boring
Reaming
Commercial Grinding
Milling – Carbides
Gear Shaping
Barrel Finishing
Roller Burnishing
Diamond Turning
Diamond & Precision Bor'g
Precision Finish Grinding
Honing
Production Lapping
Superfinishing
Aluminum
Brass
Cast iron
Soft steel
Hardened steel
KEY
Usual average or most economical range
Full range commercially used
Average Machine Finishes
Noncritical Parts
Average Parts
Critical Parts
Small sizes and dimensions
Tolerance range
Large sizes and dimensions
General trend of cost curve
Relative Cost (in units of time required)
Applicable Typical Dimensional Unilateral Tolerances (in.)
0.00001
0.00002
0.00003
0.00005
0.00008
0.0001
0.0002
0.0003
0.0005
0.0008
0.001
0.002
0.003
0.005
0.008
0.010
0.013
0.016
0.020
0.025
0.032
0.040
0.050
0.063
0.080
0.100
0.125
0.160
0.200
0.250
Surface Finish (microinches, rms)

preciation of low-cost mass-production technique. Interchangeability is the key to successful production regardless of quantity and details of all parts should be surveyed carefully to assure not only inexpensive processing but also rapid, easy assembly and maintenance.

It must be remembered that each production method has a well-established level of precision which can be maintained in continuous production without exceeding normal basic costs. No amount of inspection will improve this level and for practical low-cost design it must be observed.

The practice of specifying tolerances on parts according to empirical rules based upon the size of the dimension must be abandoned as uneconomical. Practical design requires consideration as to how the part must be produced—milling, casting, single-point turning, molding, grinding, and so on. Where precise data as to the actual "natural" tolerances of any specific process are desired, quality control procedures will enable this information to be obtained with ease. An illustration of how conventionally established tolerances compare with the actual natural tolerances[12] of different machines can be found in TABLE 2. The fallacy of conventional tolerancing is at once apparent. It is also apparent that minimum tolerances characteristic in any process should *never* be demanded unless some such statistical procedure has established the capability of the equipment at hand. Age, maintenance, tooling, etc., can have a considerable effect on practical operation costwise.

Much the same as with dimensional tolerances, surface finish or roughness specified should be the maximum acceptable. Wherever possible, the inherent average finish left by the basic process should be contemplated. In the chart of *Fig.* 18 are shown the common metal removal and finishing processes with their full range of surface roughness encountered in commercial practice. Also shown are the narrower ranges of finish normally expected in average production that are not the very finest but which can be generally anticipated with well-kept equipment without incurring undue expense. Finish readings are in microinches, root-mean-square values. Natural surfaces characteristic with the nonmachining processes are given in *Fig.* 19.

The chart of *Fig.* 18 also shows at a glance the general relationship of actual dimensional tolerances to surface roughness. Here also the trend of cost is shown and the increasing expense of decreasing tol-

TABLE 2—NATURAL MACHINE TOLERANCES
(inches)

Machine	Tolerance	Drawing Specifications
External Grinders		
1. Universal	0.00048	4.288/4.289 diam of groove
2. Plain	0.00634	0.165/0.180 face step
3. Plain	0.0007	5.875 (+0.000 −0.001) OD boss
4. Plain	0.0008	5.875 (+0.000 −0.001) OD boss
5. Plain	0.00094	4.4999 (+0.000 −0.0013) diam
6. Plain	0.00098	4.9061 (+0.000 −0.0013) diam
7. Plain	0.00094	7.1873 (+0.000 −0.001) diam
8. Plain	0.0026	0.375 (+0.005 −0.000) flange thick.
9. Plain	0.00094	4.4999 (+0.000 −0.0013) diam
10. Plain	0.00098	4.9061 (+0.000 −0.0013) diam
11. Plain	0.00078	5.4998 (+0.000 −0.001) diam
12. Plain	0.00088	6.0935 (+0.000 −0.001) diam
13. Plain	0.00084	6.3748 (+0.000 −0.001) diam
14. Plain	0.00078	7.1873 (+0.000 −0.001) diam
Internal Grinders		
1.	0.00048	3.877/3.875 ID bore
2.	0.00072	4.813/4.820 ID bore
3.	0.00091	8.5007 (±0.0005) ID
4.	0.00077	5.3757 (±0.0005) ID
5.	0.00173	7.599 (±0.001) ID
6.	0.00084	5.7819 (±0.0005) ID
7.	0.00177	8.469 (±0.001) ID
8. Single lobe	0.00128	1.381/1.393 width of track
9. Single lobe	0.00457	1.381/1.393 width of track
10. 4 lobe	0.0084	1.631/1.643 width of track
11.	0.0014	0.625 (+0.0005 −0.001) ID lug hole
12.	0.00144	1.631/1.643 width of track
13.	0.00234	1.881/1.893 width of track
14.	0.003	7.260/7.250 ID arm bore
15.	0.0016	6.381/6.373 centerline to thrust face
16.	0.00198	6.755/6.750 ID cross bore
17.	0.0027	11.515/11.485 ID dome shelf
18.	0.00114	11.6925/11.6825 ID dome shelf
19.	0.0025	11.766/11.751 thd. bore diam
Lathes & Turret Lathes		
1.	0.0024	8.675/8.680 OD of groove
2.	0.014	$6\frac{7}{8}$ (±0.010) centerline cam roller shaft to bottom of ID
3.	0.012	8.235/8.250 OD
4.	0.0065	11.932/11.912 groove diam
5.	0.0028	9.165/9.135 bore diam
6.	0.00636	4.4464 (+0.005 −0.002) spline bore diam
7.	0.00217	3.678/3.698 ID bore
8.	0.003	5.560/5.580 OD
Miscellaneous Machines		
1. Drill Press	0.01559	0.302/322 centerline of tapped hole
2. Drill Press	0.0032	2.335/2.305 spot face dimension
3. Drill Press	0.001	0.635/0.625 diam bolt hole
4.	0.0027	5.135/5.115 bore diam
5.	0.0034	5.196/5.901 bore diam
6. Th'd. miller	0.006	11.829/11.817 pitch diam
7. Th'd. miller	0.0031	10.4545/10.4425 pitch diam

Fig. 18 — Chart showing basic machining processes, their overall and normal commercial range of surface roughness, and their accompanying range of practical dimensional tolerances. Rational tolerance ranges are merely indicative and should not be applied without adequate study of the process under consideration

NATURAL SURFACES

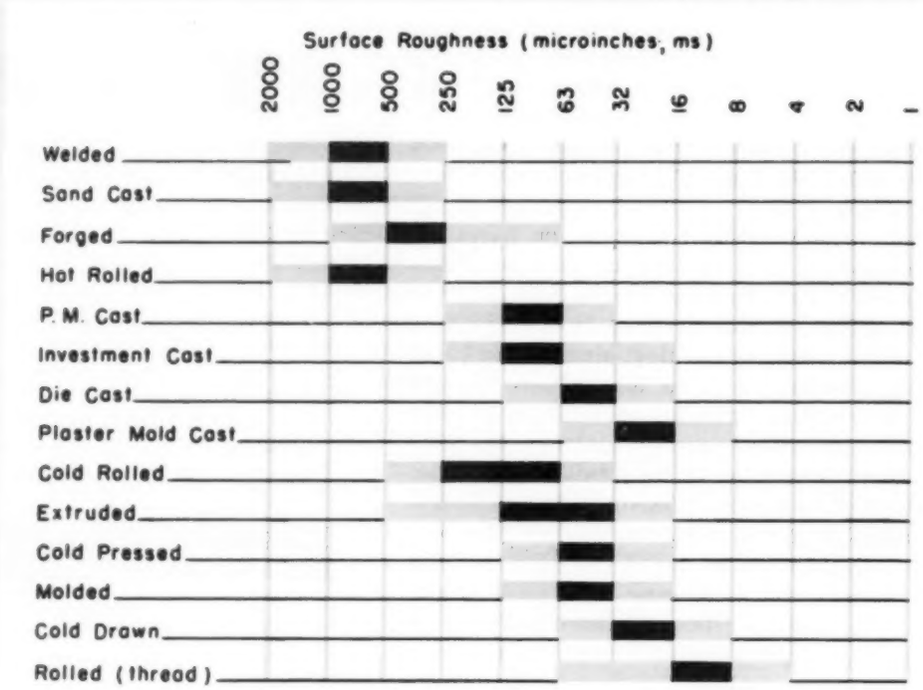


Fig. 19—Chart showing overall and average range of natural surface roughness characteristic with the nonmachining processes

* With regular cross-hatch pattern
† Smoothest possible finish
‡ Waviness not considered

Fig. 20—Characteristic maximum surface roughness for common machine parts. Charted from various manufacturer's practices on such parts, these data will assist in judging practical finishes

erances is exemplified. In no case should any of these values be applied promiscuously—they are primarily indicative and, owing to the many idiosyncrasies and ramifications which necessarily characterize any production method, all designs should be considered separately to take into account such factors as size, shape, complexity, etc.

In relation to surface finish or roughness it must be remembered that each process produces a characteristic type or types of surface finish pattern. Finish specifications where important, should not be general or susceptible of misinterpretations. Use of approved[13] methods of specification will prove well worthwhile. Functional requirements should be carefully analyzed in determining the maximum satisfactory surface roughness value to specify. Characteristic maximum surface values shown in *Fig.* 20 will assist in judging what constitutes a practical finish. Study of each processing method will provide the clue to the pattern to be expected and the suitability of the part so produced for the intended use.

AS MANY case studies have proved, few parts are produced that cannot be improved in design and reduced in cost. While improvement from a production-cost standpoint is not only desirable but imperative, the functional or physical design characteristics affected are also important. It is in this phase that the final value of producibility lies.

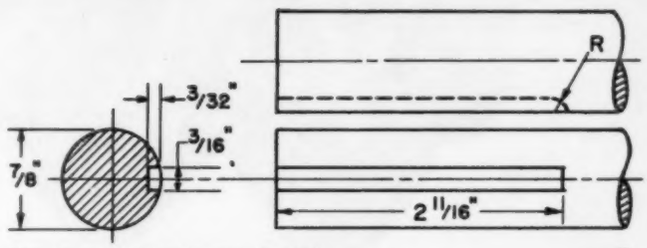
The aim in designing or redesigning for manufacture is, of course, always to achieve lower or, more rightly, minimum costs without seriously affecting the designed or inherent functional characteristics. While this goal cannot be reached invariably, in those few cases where it appears impossible a new design approach generally can be employed to solve both problems simultaneously. However this may be, moves in the direction of redesign for manufacture are most generally disputed on the basis of incompatibility regarding function. Facts do not substantiate such arguments.

What, then, is the actual case—is functional design ever incompatible with producibility? Generalizing, the answer is an emphatic No! The actual fact is that for maximum overall benefit, functional design and production design must be compatible. When the optimum degree of coexistence has been reached—for a specified set of conditions—then optimum physical and production characteristics generally have been achieved also.

Thus it is that out of the search for producibility, greatly improved service life and product quality often result. These largely unexpected dividends many times can reflect back into further cost reductions when design is modified to provide only the expected or practical service life required.

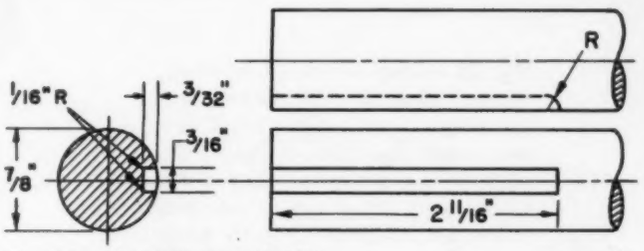
A few pertinent case studies which follow attest to the veracity of these far-reaching maxims, and assist in visualizing the multiple latent possibilities in good production design which all too seldom are tapped to real benefit. The simple fillet, too often neglected, is perhaps one of the basic design cases. Fillets not only decrease production costs in adding to cutting tool, die and mold life but increase strength and fatigue life tremendously when properly employed. A recent example of this particular factor was given by Schall[14] and dealt with crankshaft cheek fillets. The increase of the radius from $\frac{1}{16}$ to $\frac{3}{32}$-inch minimum, increased life at critical speed from

Square Corner Keyway



Number of specimens tested 3
Average number of blows to break 6,722

Fillet Corner Keyway



Number of specimens tested 3
Average number of blows to break 12,360

Fig. 22—Comparative values for keyways in Monel propeller shafts tested under fatigue. Corner fillets double the strength of the shaft

Drawing, courtesy International Nickel Co.

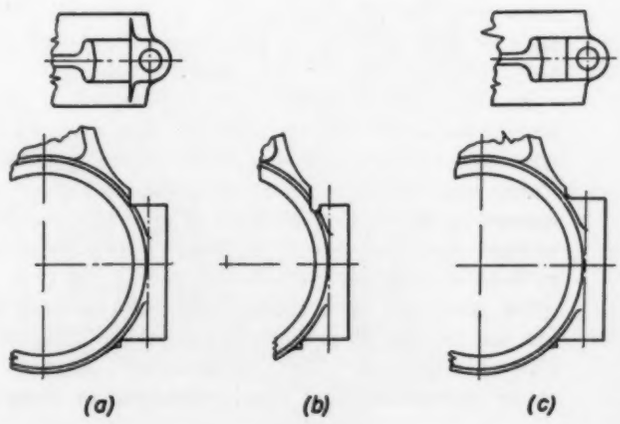
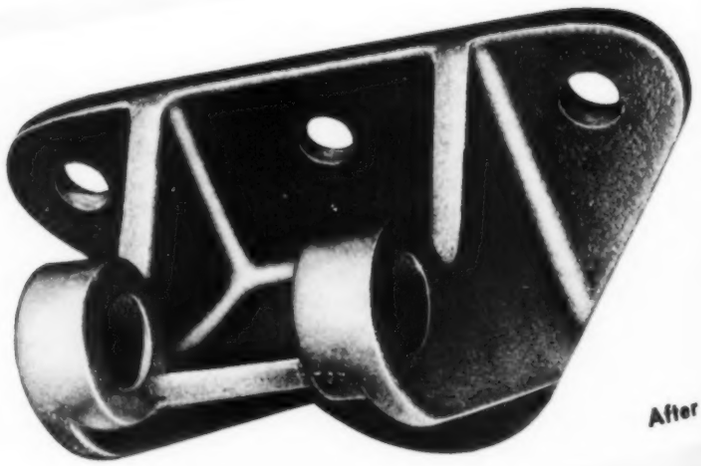


Fig. 21—Alternate design with fillets, b and c, eliminated failures encountered with sharp-corner bolt boss machining of connecting rod as at a

Before



After

Fig. 23—Original hinge casting, above, proved too expensive. Redesign, right, eliminated two cores and reduced weight from 12.2 to 9.8 pounds. Cores for hinge pins were made integral to insure alignment with base and ribs were redesigned not only to simplify casting but to place them in compression as a unit rather than bending

Photos, courtesy Superior Steel and Malleable Castings Co.

less than 50 hours to an indefinite length. With connecting rods, *Fig.* 21, failures were encountered with the sharp-cornered milling of the bolt boss as shown at *a*. The undercut radius used at *b* eliminated failures even though the section was reduced. New design as at *c* includes a generous radius and greater section to increase strength still further.

Another case somewhat more complex is the well-known keyway. The temptation is always to design with round-end keyways having vertical profiled ends. These generally look nicer on paper and often appear necessary for key retention. The first consideration is that these are more expensive; they must be end milled—a slow operation—or drilled at the ends—often too deep—and shaped out. The second consideration is that round-end keyways are fatigue sensitive at the ends. The "sled-runner" keyway is far more economical and much stronger in fatigue. It permits rapid production with standard cutters. In addition, filleted corners can be added to still further increase practical fatigue life while maintaining the production advantages of the cutter runout design, *Fig.* 22.

Common foundry practice is to produce castings strictly in accordance with customer specifications and design—frequently incompatible with material castability and efficient foundry procedures. The result is high costs arising from scrap in casting, losses in machining, and worst of all, but not always least, early failures not truly the fault of the process.

Properly designed castings not only result in reasonable costs but very often produce a superior product with distinct advantages. In *Fig.* 23 is shown a hinge bracket which when redesigned for economical casting not only reduced cost by 15.9 per cent but created a stronger casting by placing the ribs in

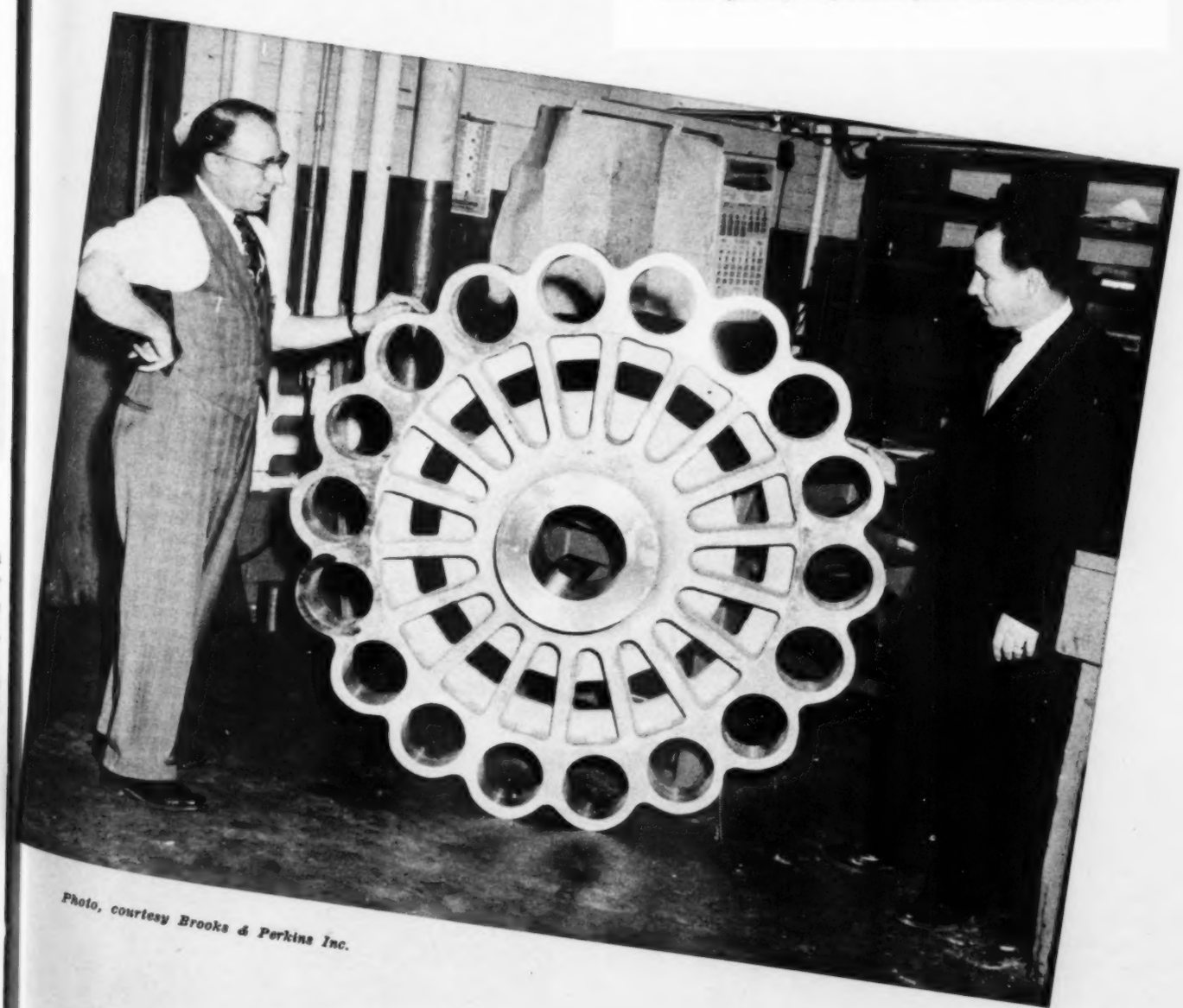
direct compression rather than in bending.

Primary production cost is not always a good criterion for judgment without full consideration of subsequent operations. For instance, although magnesium alloy castings are more costly than gray iron, the cost after machining often proves to be lower, *Fig.* 12. In the mechanical press clutch housing shown in *Fig.* 24 the use of magnesium also resulted in a decrease in starting and stopping time, a decrease in starting load and reduced overall power requirements.

Assembly or fabricating operations are especially important considerations when production-function compatibility is to be analyzed. Use of the most suitable methods available produces gratifying results. An outstanding example of this category is found in a recent application of resistance welding on the stiffeners and skin assembly of a jet engine fighter plane control surface. Replacing riveting, roll-spot welding reduced production time by 29 hours per unit of two surfaces, TABLE 3. Advantages over and above cost savings included greatly improved aerodynamic surfaces and actual increase in strength of approximately 600 pounds per fastening, i.e., weld spot.

In the search for more economical methods of processing, the possibility of eliminating production operations offers a fertile field for cost savings. In this area powder metallurgy can be extremely effective. The textile winding machine cam shown in *Fig.* 25 was originally made from SAE 1112 bar-

Fig. 24—Large clutch casting for Hamilton mechanical presses. Use of magnesium provides greatly improved press characteristics



Photo, courtesy Brooks & Perkins Inc.

TABLE 3—COMPARISON OF CONTROL SURFACE SKIN ASSEMBLIES

(0.016-in. 24ST to 0.016-in. 24ST Alclad)

Operation	Amount		Time (min)	
	Riveted	Welded	Riveted	Welded
Drilling, burring, dimpling..	4076	432	787	83
Riveting	4076	432	271	30
Cleaning	....	...	...	7
Roll-spot welding	3644	...	...	61
Total time per unit	....	...	1058	181
Total time per ship	....	...	2116	362

* Courtesy Sciaky Bros, Inc.

stock, but machining was expensive. Produced from sintered iron, the cam cost some 20 per cent less. Because of the damp environment, corrosion resistance was necessary, especially with such compacts. By treating with the Keyonyx H process, in which magnetic oxides are formed on all exposed particle areas throughout the material, the iron is made corrosion resistant and wear resistance is greatly improved. As a consequence, besides a substantial cost advantage, service life was increased by 400 per cent.

Many more examples of cost savings and production improvements which resulted in functional advantages could be cited. However, these specific cases should offer sufficient evidence of the potentials. Producibility must be actively sought. It seldom evolves automatically. Once engineering design includes adequate consideration of this important aspect, the overall results not only in dollars-and-cents but in quality and in service life are no less than amazing.

Fig. 25—Textile winding machine cam produced from sintered iron resulted in a 20 per cent cost reduction. Keyonyx treatment for corrosion resistance increased the cam service life 400 per cent

The possibilities of producibility are tremendous and are largely untapped. From a cost standpoint it becomes obvious that the advantages of good design for production should be sought seriously. Today, perhaps even greater stress must be placed on the conservation of our far from limitless engineering materials and upon achieving better results with smaller amounts. The practicability of the design for production approach has been validated. The accomplishments merely await the careful studied application of these principles.

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Nomogram Simplifies

Worm and Gear Design

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WORM reduction units are frequently designed by trial-and-error methods. That is, certain dimensions of the worm or of the gear are first selected and the remaining dimensions calculated from or checked against such factors as strength, wear, efficiency, and heat dissipation.

In this data sheet, relationships between several of the variables are developed from recommendations in current use* and a nomogram is presented to solve the resulting equations. Although a design obtained from these considerations might require modification to satisfy certain requirements, it will provide a rational basis for the final selection of the reduction unit.

Power to be transmitted, speed of the worm, and reduction ratio are quantities that are specified according to the duty which the reduction unit has to fulfill. Relatively few materials have been successfully used in worm drives; for the majority of applications a combination of phosphor bronze gear and hardened steel worm has proved satisfactory. However, to keep the treatment general, substitution of the appropriate material values in this discussion is left to the designer.

Pitch-line load can be calculated from power transmitted and pitch-line velocity (see Nomenclature):

$$W = \frac{33{,}000P}{v} \quad \ldots\ldots (1)$$

The maximum instantaneous tooth load exceeds this value due to dynamic effects, and may be written

$$W_d = \frac{1200 + v}{1200} W \quad \ldots\ldots (2)$$

The usual design criterion is that the wear resistance should at least equal the dynamic load, whereas the strength of the tooth should exceed it by an amount depending on the margin of safety required.

From the usual relationships for wear resistance and beam strength,

$$W_w = DFk = W_d \quad \ldots\ldots (3)$$

$$W_s = spFy = (1 + m)\, W_d \quad \ldots\ldots (4)$$

Since $D = N_G p/\pi = (N_G/N_W)\, N_W p/\pi$, Equation 3 can be written

$$\left(\frac{N_G}{N_W}\right)\frac{N_W pFk}{\pi} = W_d \quad \ldots\ldots (5)$$

Combining Equations 4 and 5

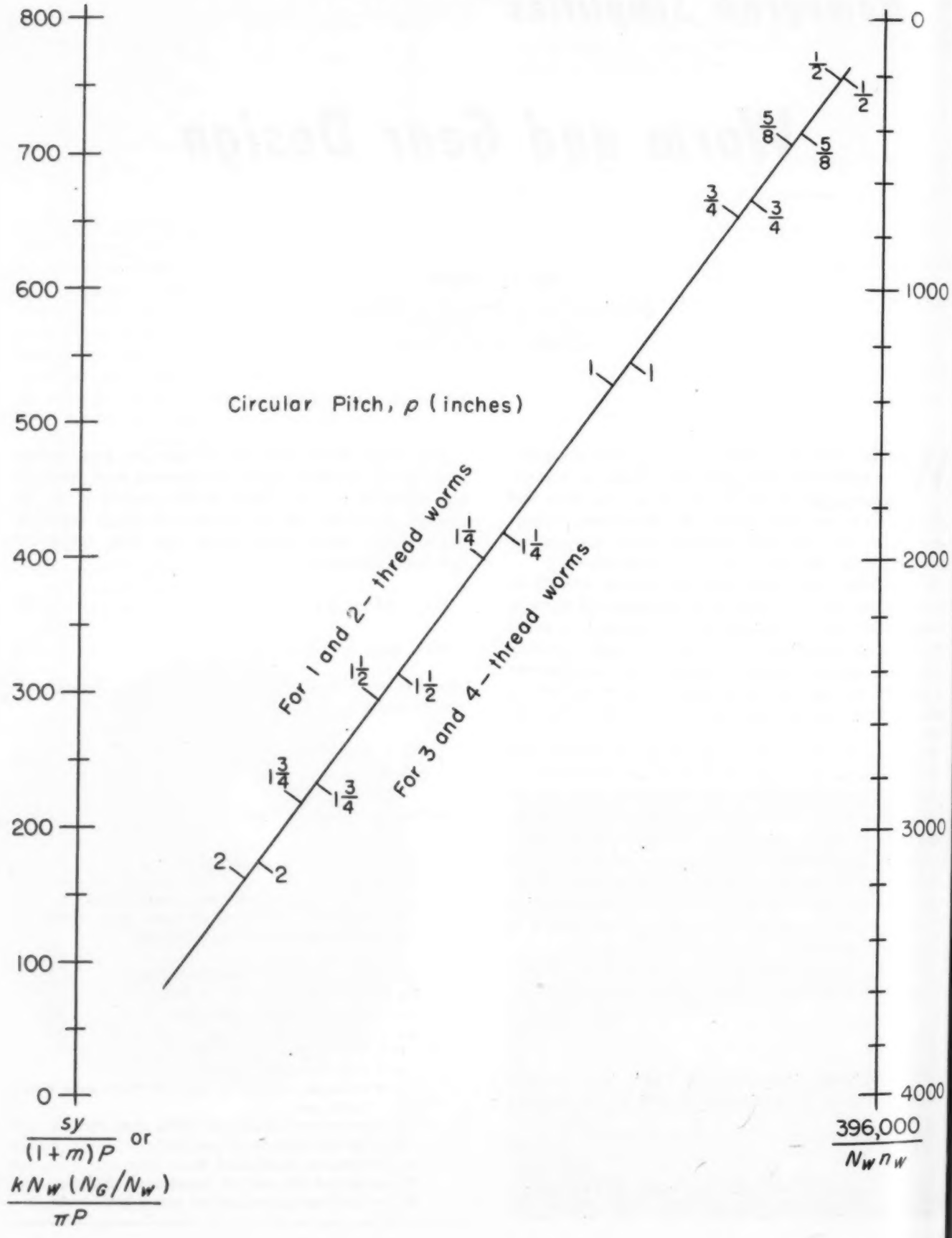
Nomenclature

D	= Pitch diameter of worm gear, inches
F	= Effective face width of worm gear, inches
k	= Wear constant of material, psi
m	= Margin of safety
N_G	= Number of teeth on worm gear
N_W	= Number of threads on worm
n_G	= Speed of worm gear, rpm
n_W	= Speed of worm, rpm
P	= Transmitted power, hp
p	= Circular pitch, inches
s	= Flexural endurance limit of worm-gear material, psi
v	= Pitch-line velocity of worm gear, fpm
W	= Transmitted tooth load, lb
W_d	= Dynamic tooth load, lb
W_s	= Safe static load on worm-gear teeth, lb
W_w	= Limiting wear load on worm-gear teeth, lb

* *Kent's Mechanical Engineers' Handbook, Design and Production Volume*, John Wiley and Sons Inc., New York, Twelfth Edition, 1951, Pages 14-42 and 14-43.

Data Sheet

Chart for Determining Pitch of Worm-Gear Units



$$N_W = \frac{\pi s y}{k\left(\frac{N_G}{N_W}\right)(1+m)} \quad \ldots\ldots (6)$$

Since the right-hand sides of these equations depend on the material (s and k), the tooth form y, the reduction ratio, N_G/N_W, and the required margin of safety m, the number of threads of the worm N_W can be calculated. For the gear, N_G can then be quickly determined from N_G/N_W and N_W.

For phosphor bronze s = 24,000 psi and k = 100 psi. For 20-degree pressure angle teeth, y = 0.125 for all practical purposes. Thus from Equation 6, $N_W = 47/(1 + m)(N_G/N_W)$.

Naturally, an integer must be selected for N_W. If the integer selected is larger than the value calculated from Equation 6, strength considerations should be used in the selection of the tooth dimensions. If the value of N_W selected is less than calculated, wear will be the limiting factor.

To find the pitch to be used, Equations 1, 2 and 4 are combined:

$$spFy = (1+m)\left(\frac{33{,}000}{v} + 27.5\right)P \quad \ldots\ldots (7)$$

For the width of the gear, AGMA recommends f = 2.38 p + 0.25 for single and double-thread worms, and f = 2.15 p + 0.2 for three and four-thread worms. Or generally,

$$F = c_1 p + c_2 \quad \ldots\ldots (8)$$

The pitch-line velocity may be written as

$$v = \frac{\pi D n_G}{12} = \frac{pN_G n_G}{12} = \frac{pN_W n_W}{12} \quad \ldots\ldots (9)$$

Substituting from Equations 8 and 9 in Equation 7 and rearranging gives for the beam strength requirement

$$\frac{sy}{(1+m)P} = \frac{\frac{396{,}000}{N_W n_W} + 27.5p}{(c_1 p + c_2)p^2} \quad \ldots\ldots (10)$$

Similarly, if wear limits the design, Equations 1, 2, 5, 8 and 9 combine to give

$$\frac{kN_W\left(\frac{N_G}{N_W}\right)}{\pi P} = \frac{\frac{396{,}000}{N_W n_W} + 27.5p}{(c_1 p + c_2)p^2} \quad \ldots\ldots (11)$$

The left-hand sides of Equations 10 and 11 contain known quantities only. On the right-hand side, c_1, c_2 and $N_W n_W$ can be assumed to be known. Pitch p can be calculated. The accompanying nomogram will facilitate the finding of p.

EXAMPLE: Assume the following properties: transmitted power P = 5 hp, worm speed n_W = 340 rpm, reduction ratio N_G/N_W = 20, and margin of safety m = 0.8. Let the gear be phosphor bronze (s = 24,000 psi, k = 100 psi) and the worm, hardened steel. Pressure angle = 20 degrees (y = 0.125).

From Equation 6,

$$N_W = \frac{\pi(24{,}000)(0.125)}{100(20)(1.8)} = 2.6$$

If N_W = 2 is selected, wear resistance is the criterion and Equation 11 should be used in conjunction with the nomogram. If N_W = 3 is chosen, beam strength, Equation 10 should be used. Number of gear teeth N_G = 40 or 60, respectively.

For N_W = 2, from the left-hand side of Equation 11,

$$\frac{kN_W\left(\frac{N_G}{N_W}\right)}{\pi P} = \frac{100(40)}{\pi(5)} = 255$$

From the right-hand side of Equation 11,

$$\frac{396{,}000}{N_W n_W} = \frac{396{,}000}{2(340)} = 582$$

A line joining 255 on the left-hand scale of the chart and 582 on the right-hand scale cuts the diagonal pitch scale at 1-inch pitch, approximately, for a 2-thread worm.

For the alternate solution, for N_W = 3, the left-hand side of Equation 10 is

$$\frac{sy}{(1+m)P} = \frac{24{,}000(0.125)}{1.8(5)} = 333$$

From the right-hand side of Equation 10,

$$\frac{396{,}000}{N_W n_W} = \frac{396{,}000}{3(340)} = 388$$

Using these two factors with the chart gives p = ¾-inch for a 3-thread worm.

ADDITIONAL DATA: The outlined method is also applicable to different pressure or thread angles and other materials than those mentioned. The following constant values may be used for the form factor with the indicated angles.

Thread Angle (degrees)	Lewis Form Factor y
14½	0.100
20	0.125
25	0.150
30	0.175

For various worm-gear materials, the following values for flexural endurance limit and wear constant may be used.

Worm Gear Material	Flexural Endurance Limit s (psi)	Wear Constant k (psi)
Cast iron	12,000	50
Manganese bronze	17,000	80
Phosphor bronze	24,000	100

Minimum margin of safety, m, for steady loads should be 0.25; for shock loads, 0.50.

DESIGN ABSTRACTS

Automatic Gaging Machine

. . . for checking critical dimensions and joint strength of a two-piece component

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PRODUCTION quantities of manufactured articles in Canada, as in any country, are limited by the population and purchasing power of the people. In comparison with that for American markets, Canadian manufacture is relatively small, and in most fields, cost of production is higher because of the limit on capital expenditure possible.

The result is that we are forced to engineer in such a manner as to meet these conditions and, of necessity, to evolve methods using work simplification to the utmost, and to apply very careful consideration to design and cost of tooling.

To demonstrate our approach to the problem, let us consider a machine for gaging, and for sorting out the defectives, on a part known as the "protector block," a device used to protect telephone instruments from damage, and telephone users from harm, should a line carrying power come in contact with a telephone line.

The annual production of protector blocks is about 2,000,000, a relatively low quantity as compared with American production. *Fig.* 1 shows the protector block for the inspection of which the machine to be described was designed. The part consists of a ceramic block in which there is a carbon insert, held in place by a lead-borate cement. The whole block is not very large, has a rather frail section and is brittle and fragile.

In *Fig.* 2 are illustrated the dimensions and requirements which are to be gaged and tested and for which the gaging-and-sorting machine was to be designed. Numbered in the order in which the checks are made, the requirements are as follows:

1. A 15-lb load is applied to the carbon insert in one direction
2. A 5-lb load is applied in the opposite direction. The insert shall not move under these pressures
3. A dimensional check of the distance from the face of the porcelain block to the spring-contact surface of the insert is necessary to insure uniformity of spring pressure
4. The side wall of the porcelain block above the insert acts as a guide in assembly, and must be checked for height
5 & 6. Location of the sparking surface in relation to the face of the porcelain is to be gaged.

Note that the 0.0028-in. dimension is held to plus or minus 0.0004-in. on a surface 0.110-in. by 0.370-in. and that four places on each block are gaged. During this gaging, an 8-lb load is applied on the spring surface of the insert with a 1-lb pressure on each of the gaging plungers.

The first step taken toward the provision of inspection facilities for the requirements, shown in *Fig.* 2, was to consider just how the inspection could be done, what gages would be required, and what the cost of inspection would be for the 2,000,000 blocks per year.

Production methods were being established on the basis of automatic and semiautomatic machines. This fact, coupled with the importance of the dimensions, particularly those for the air gap and the pressure test, made it imperative that parts be gaged in 100 per cent detail.

Three analyses were made, with tentative designs of gages and their costs and productive rates estimated. The first analysis, based on hand-loaded and hand-operated gages, re-

Fig. 1—Protector block for which gaging machine was designed

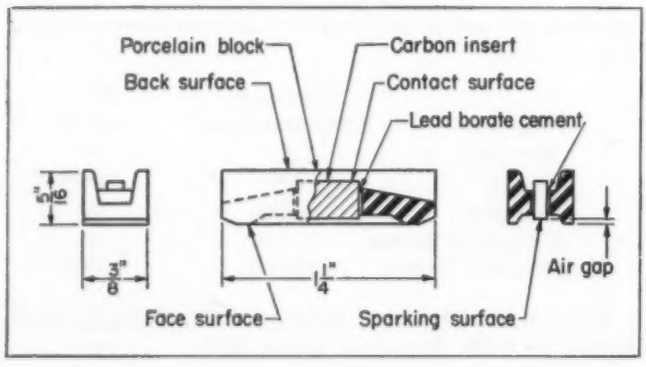
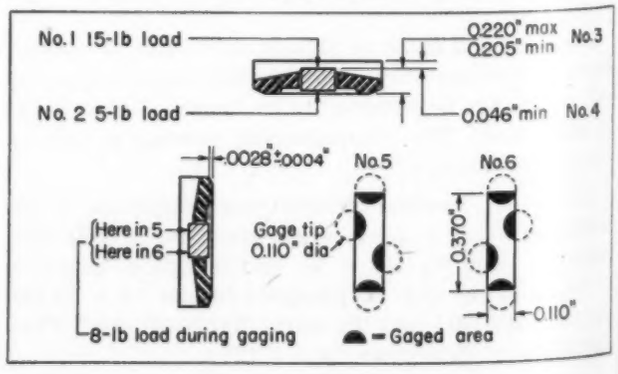


Fig. 2—Dimensions and gaging requirements of protector block



vealed that these would cost $5000, and that the annual inspection time would be 14,000 hr (at 90 per cent efficiency). A further study showed that inspection time could be reduced to about 7000 hr by partially mechanizing and otherwise increasing the output of the various individual gages. This, however, would increase the cost to $10,000.

Finally, it was proposed to combine all the gages in one mechanized unit in which all six inspection operations would be performed simultaneously. At a speed of operation of 3000 parts per hr, the time would be 1000 hr yearly for the 2,000,000 parts. This time would be one half of one shift, leaving plenty of time for any maintenance which might be required. A cost limit of $20,000 was established as the probable cost, and also as the most capital which would be available.

The cost comparison, illustrated in TABLE 1, shows that we were justified in deciding to proceed with the design of a multiple automatic gaging machine.

A multiple gaging unit having been agreed upon, the next decision to be made was that of the general arrangement of the gaging stations, and the method of conveying parts from station to station. This could be done in one straight line or by a rotating arrangement. The straight-line method would result in a rather long machine and would probably require a return conveyor capable of affording the desired accuracy of location at each station.

Table 1—Comparison of Method vs Cost

Method	Capital	Cost in Dollars — Yearly — Inspect[a]	Total[b]
A	5000	14000	15000
B	10000	7000	9000
C	20000	1000	5000

[a] Based on $1.00 per hour

[b] Incl. 20 per cent depreciation and maintenance

A rotating carrier with nests into which parts could be inserted and indexed to come to rest for gaging on a stationary base, was adopted as being more compact. Since there are two sizes of blocks, the fact that a ring-shaped carrier could be more readily changed over influenced the decision in favor of a rotating arrangement.

General mechanical requirements for the design of the machine were established as follows:

1. Utilization of standard, readily obtainable and replaceable commercial units
2. Hand-loading which would permit the operator to discard broken and obvious defectives. This to be the only manual feature
3. A production rate of 3600 per hr, with some lower speed available for trainees, if necessary
4. Sorting of defectives at each stage
5. Gaging units or heads to be easily set or adjusted, and retain their accuracy
6. Accessibility of the mechanism for adjustment and for removability of units for maintenance and cleaning
7. Controls to permit continuous operation and also single-operation jogging for adjusting to master blocks
8. Use of carbide and/or chrome plate on surfaces subject to wear
9. Compactness, convenient operator height, pleasing general appearance.

The sequence of the gaging operations had now to be determined. The carbon insert is held in place by the lead-borate cement. If the insert be loose, the block is defective. Therefore the 15 and 5-lb pressure tests were selected to be made first, and

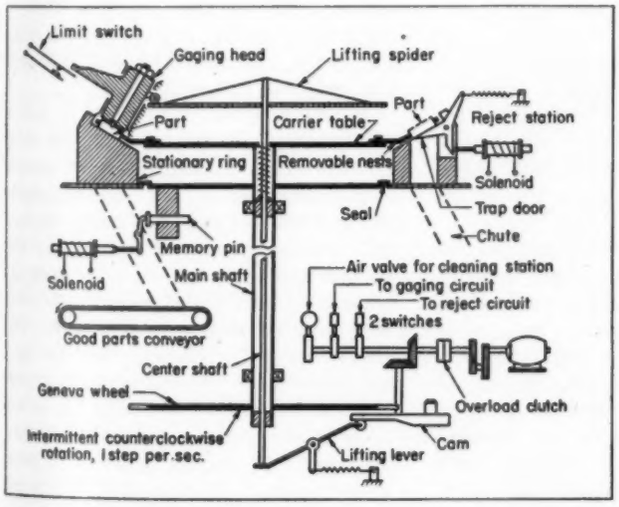


Fig. 3—Above—Elevation schematic of gaging machine

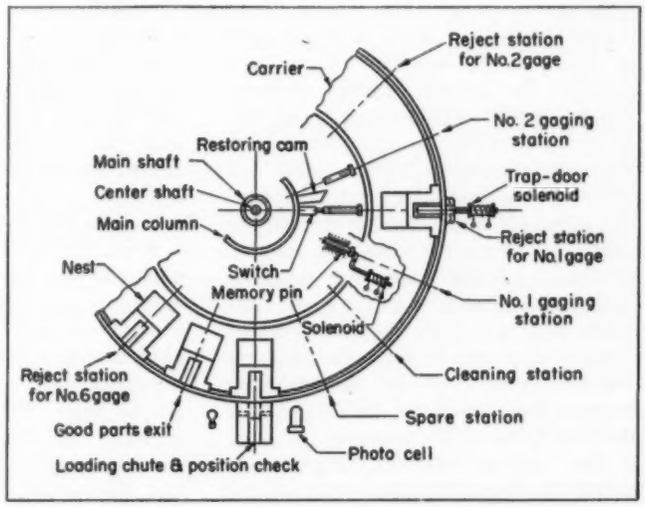


Fig. 4—Above—Plan view schematic of block carrier

Fig. 5—Below—Timing chart for one cycle

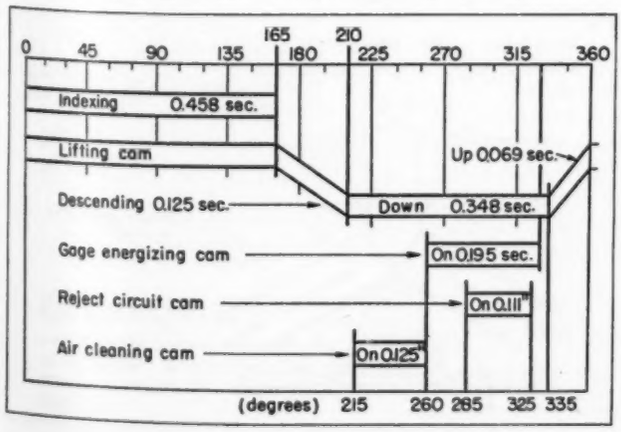
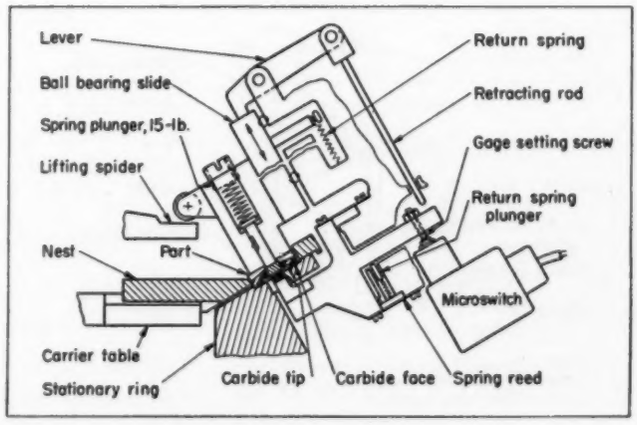


Fig. 6—Below—Details of first gaging station



the most important test, the air-gap requirement, to be made last.

For the sorting action it was planned that solenoid-operated drop-out gates would be used. Some form of amplifying limit switch would be required to operate the solenoids, and commercially available units, of which there are a number on the market, were selected.

For three stations, namely, the 15 and 5-lb tests and the minimum 0.046-in., simple unidirectional micro-switches were used. For the 0.220/-0.205 dimension, a self-contained adjustable gage was chosen. This device has a high amplification through its reed leverage principle. For the air-gap requirement (checked twice, each at four spots) air-electric gages were selected. In these, a change in dimension of part being gaged affects air pressure on a Bourdon tube, which in turn actuates the adjustable switch contacts.

Although the rotating members were designed to have the minimum weight possible, there is considerable inertia to overcome in stopping them. For this reason a reversing motor drive and a zero-speed cutout were utilized, together with an overload clutch.

The succeeding stage in design was to lay out the number of stations required for loading, gaging, sorting, and unloading. This came to 14, but 16 were specified to simplify design and construction problems. This left two vacant, but later one was used for cleaning and one for a position check. A Geneva motion was adopted as that best applicable for indexing and locking each position. A time chart was prepared to insure maximum dwell for gaging and sorting and yet not accelerate the indexing beyond safe margins. This chart will later be examined in detail.

The loading of this fragile protector block without damage and breakage was studied, and various loading methods were tried out experimentally. The method finally selected was to slide the parts down a chute on a 30-deg incline, with the later addition of air jets which accelerate and simultaneously cushion the part as it slides directly into its nest.

Schematics outlining the construction of the machine are given in *Figs.* 3 and 4. In *Fig.* 3 is shown the carrier table on which is a series of nests into which the parts are loaded, passed around on the stationary ring and presented in turn to the various gages. These nests are removable for repair and for exchanging for the two sizes of protector blocks which are gaged on the machine. Following each gage is a means of ejecting defective parts into pans. A part acceptable to all gages is finally dropped on a conveyor. The main shaft rotates counterclockwise and intermittently, through the Geneva stop mechanism which is driven by the pin in the cam and locked by the half pin on the center of the cam. The cam, driven at 60 rpm, lifts the spider on the center shaft by means of a lever. The spider, in turn, raises all gaging heads simultaneously to clear the parts while they are being indexed.

As each gaging head descends, it clamps the part and helps to lock the carrier table which is rigidly fixed to, and rotates with, the main shaft. Should the part be outside the limits, a gaging switch energizes the memory-pin solenoid.

When the carrier is indexed to the next station, the memory pin, now in extended position, actuates the switch energizing the reject trap door solenoid which opens the trap and permits the part to fall into the chute to the pan. This is repeated at each station. The plate under and parallel to the carrier table is rotated with the main shaft and carries the memory pins, of which there are 16.

The plate under the stationary ring and the rubber seal ring keep dirt and dust from falling on the mechanism. The Geneva wheel, the center-shaft lifting mechanism, and cams are all kept in an enclosed oil bath. The conveyor for the accepted parts is driven by its individual 40 to 1 geared-head 1/20-hp motor.

The main motor is ½-hp and has a reversing feature to effect rapid stopping of the motor and the mechanism. This is accomplished by a reversing switch and a zero-speed cutout, and is controlled by the stop button or the photoelectric tube.

In addition to driving the indexing cam shaft, the motor shaft carries three cams, two to operate limit switches, energizing the gaging and reject circuits, and one to operate the air valve which controls the air blast at the cleaning station.

The plan view schematic, *Fig.* 4, shows the arrangement on the carrier plate of the 16 nests, only a few of which are illustrated. The fragile nature of the porcelain results in a certain amount of chipping in handling. For this reason, parts are picked up and loaded manually to avoid carrying chips into the loading chute. Should the operator fail to keep the loading chute supplied with parts, the photo-electric cell will stop the machine automatically.

It was originally intended to check the position of the part at the first station from loading, but a simple protruding pin in the loading chute insured the correct side being up and this station is now a spare. At the second indexed position, a blast of air cleans out any small particles or carbon dust which may be present. The third indexed position is the first gaging station, which is that applying the 15-lb load to check for looseness of the insert. As stated earlier, the order of gaging was established deliberately, with this 15-lb test being

(*Continued on Page* 204)

Fig. 7—Details of third gaging station

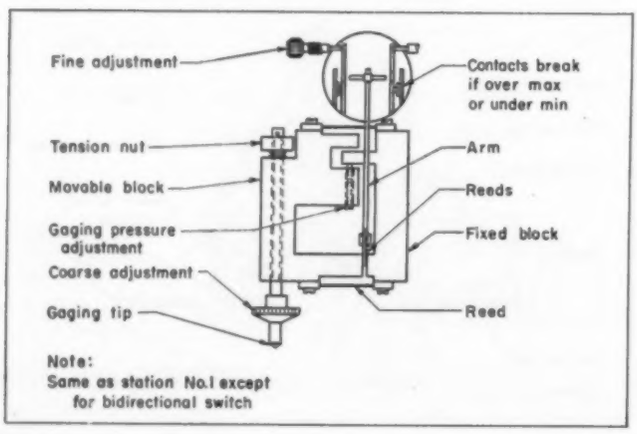
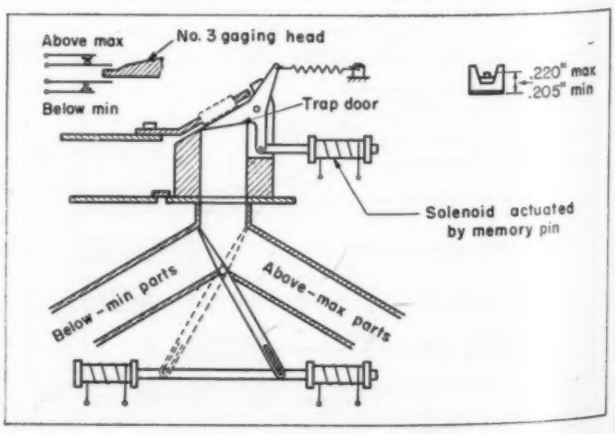


Fig. 8—Reject mechanism at third gaging station



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Naturally in some instances it is essential to design and produce a special bearing for a specific application. Such factors as flanges, wall thickness, taper, special alloys and other characteristics that cannot be provided for in stock bearings can only be secured through special manufacturing operations. This often necessitates special patterns, tools, dies or other equipment not included in the cost of stock items. With the exception of long production runs of one size, special bearings are more costly than stock items.

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Standard stock bearings are cast in what is usually referred to as a general purpose alloy, providing better than average physical properties assuring long life and excellent performance. Oil grooves, slots, or holes are easily, quickly and economically added. Standard tolerances, as listed below, can easily be altered where closer precision is required or where greater clearance is necessary.

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46 Lengths

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MEN OF MACHINES

D. R. Shoults has been appointed director of the General Electric Company's Aircraft Nuclear Propulsion project for the Air Force and Atomic Energy Commission. Purpose of the project is to develop an atom-powered engine for aircraft and will be headquartered at the company's Lockland, O., turbojet research, engineering and manufacturing center. Mr. Shoults began his engineering career with GE in 1925 after graduation from the University of Idaho. In 1941, while on a mission to England for the company's aviation divisions, he became the first American civilian to inspect Britain's then top-secret Whittle jet engine in an official capacity; he and an Air Force technical liaison officer were ordered to inspect and make recommendations on the possible American use of the Whittle engine. He became engineer of General Electric's aviation divisions in 1942 and three years later joined Bell Aircraft, where he served as vice president of engineering for two years. In 1947 he became vice president of engineering for the Glenn L. Martin Co. In May of last year, when Aro Inc. was created at the request of the Air Force to manage and operate the Arnold Engineering Development Center, Tullahoma, Tenn., Mr. Shoults became Aro's first director of engineering. He is a fellow of the American Institute of Electrical Engineers, an associate fellow of the Institute of Aeronautical Sciences and a member of the Society of Automotive Engineers.

D. R. Shoults

•

John W. Brennan was recently appointed chief engineer of the American Blower Corp. He first became associated with the company in 1928 and in 1945 was made manager of the hydraulic coupling division, with headquarters in Detroit. In his new capacity he will be responsible for engineering in all divisions of American Blower, which has plants in Dearborn, Mich., Columbus, O., and San Leandro, Calif. Products of the company include heating, ventilating, air conditioning, air handling and mechanical draft equipment and fluid drives. Mr. Brennan is a graduate of the University of Notre Dame, past chairman of the Detroit Section, American Society of Mechanical Engineers, active in the National Federation of Sales Executives, and a member of the Engineering Society of Detroit.

John W. Brennan

R. J. S. Pigott

•

Reginald J. S. Pigott has been nominated as 1952 president of The American Society of Mechanical Engineers. Succeeding J. Calvin Brown, Mr. Pigott will begin his term of office at the conclusion of the ASME annual meeting in December. He became a junior member of ASME in 1912, an associate member the following year, a member in 1918, and was made a fellow of the society in 1938. He has served on numerous committees and was vice president from 1936-1938. He served for 30 years as chairman of the Special Research Committee on Fluid Meters, and was responsible for starting this committee. He is also a past president of the Society of Automotive Engineers and was the first president of the American Society for Measurement

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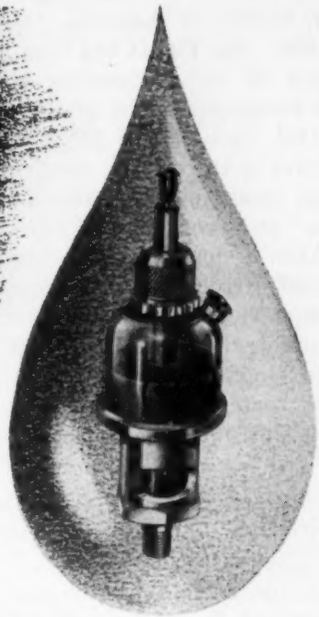

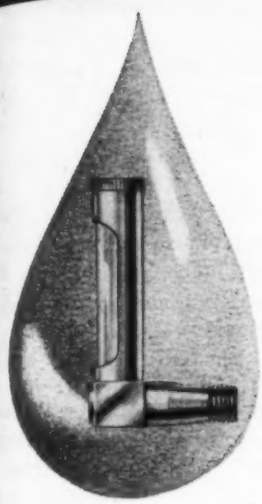

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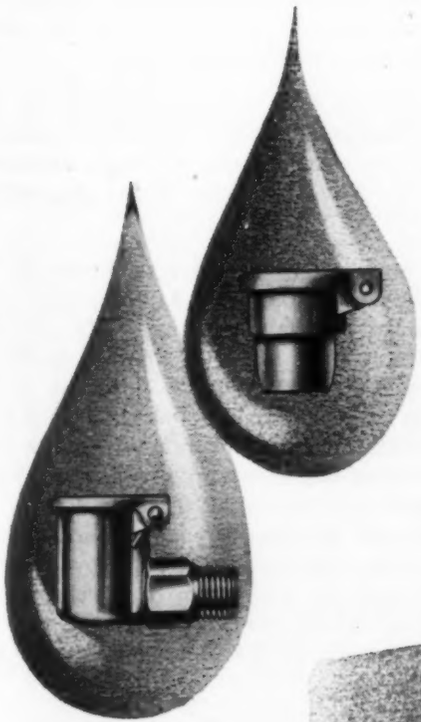

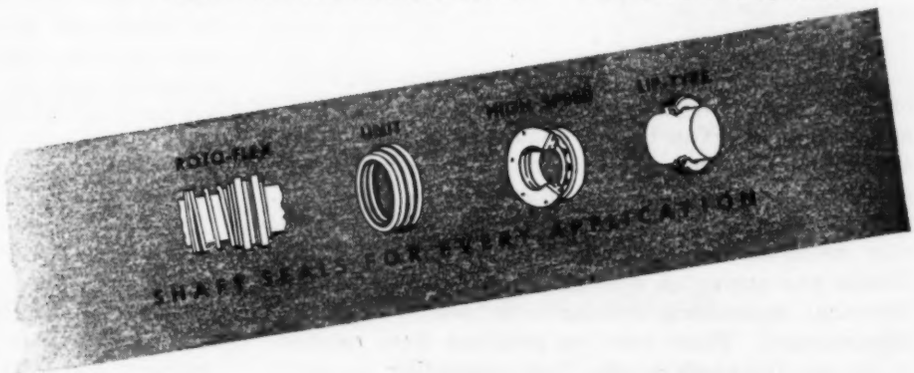

and Control, now the Pittsburgh Chapter of the Instrument Society of America. He was president of ISA in 1950. Mr. Pigott has held his present position as director of the engineering division of Gulf Research & Development Co. of Pittsburgh, a subsidiary of Gulf Oil Corp., since 1929. His record includes eleven years in the design, construction and operation of central steam power stations and seven years in designing and constructing power and industrial plants. Also, he has been concerned with metal manufacture and petroleum engineering research. He holds patents on devices used in hydraulic engineering, heating, oil production, and instruments and has written numerous technical papers on power station design, fluid flow, instruments, vapor lock, lubrication, superchargers, and aviation fuel and lubrication systems.

♦

To assume his duties on September 1, **Dr. Jess Harrison Davis** has been elected president of Stevens Institute of Technology, Hoboken, N. J. Dr. Davis will relinquish his present position as president of Clarkson College of Technology, Potsdam, N. Y., to take over the new assignment.

♦

KSM Products Inc. has named **Larry P. English** as chief engineer, with headquarters at the main plant in Merchantville, N. J. Previous to this appointment, Mr. English was district engineer for the company in the New York and New England area.

♦

In line with expansion in the research volume at Midwest Research Institute, **Martin Goland,** chairman of the engineering division, has been appointed associate director for engineering sciences. Mr. Goland came to the Institute in 1946 from the research laboratories of Curtiss-Wright Corp., where he was in charge of the structures department. His professional work has included research and development on programs involving structural aerodynamics and design aspects of combat aircraft, guidance and stability designs of guided missiles, vibration and flutter problems and many industrial mechanical design applications. He is editor of the engineering publication *Applied Mechanics Reviews* and serves on the vibration and flutter subcommittee of the NACA.

♦

In recognition of "outstanding services to industry and the engineering profession" **Alfred Iddles,** president of the Babcock & Wilcox Co., was given the honorary degree of Doctor of Engineering by Polytechnic Institute of Brooklyn at the 96th annual commencement last June.

♦

Armour Research Foundation of Illinois Institute of Technology recently announced a number of promotions. **Dr. LeVan Griffis,** chairman of applied mechanics, was named manager of a new engineering mechanics division. He will head three new departments: structural research, mechanism and propulsion research and heat-power research. **Dr. E. H. Schulz** was appointed manager of a new physics and electrical engineering division to include two existing departments. These new top positions were created to answer the needs arising from expanding research activities. **Ralph W. Fox** has been named chairman of a new structural research department at the Foundation and will head a department consisting of operating sections specializing in stress analysis, structures, materials and instrumentation. Also, **Sidney F. Musselman** and **Dr. Severin Raynor,** assistant chairmen of applied mechanics, have been named associate managers of the engineering mechanics division, and **Wilson P. Green,** assistant chairman of applied mechanics research, has been promoted to chairman of the new heat-power research department.

♦

A number of changes in the engineering organization of the Cooper-Bessemer Corp. have been announced by **Ralph L. Boyer,** vice president and chief engineer. In addition to Mr. Boyer and **E. Frederick,** assistant chief engineer, the new office of chief engineer now includes **T. O. Kuivinen, R. F. Kymer** and **W. R. Crooks** as chief engineer's assistants. Technical matters will be handled by Mr. Kuivinen, liaison activities between engineering and production will be directed by Mr. Kymer, while Mr. Crooks will assist in a general administrative capacity, also directing his efforts in research and development projects. Also announced were the promotions of **Thomas E. Eagan** to the new position of research metallurgist and **I. W. Ferguson** to manager of quality control.

♦

Jay E. Browder was recently appointed chief of the radio communications engineering section of Kollsman Instrument Corp. Mr. Browder has done engineering research on automatic direction finders, airborne radar equipment, microwave communication systems and microwave instrument landing systems. Prior to joining Kollsman, he was on the engineering staff of the Sperry Gyroscope Corp.

♦

Henry Thompson has been appointed chief engineer of Instrument Gear Works, Chicago, succeeding the late John M. Graven, founder of the company.

♦

Three engineering executives, **Bruce R. Wright, John T. Odbert** and **Michael J. Toth,** have joined the steam specialty division of the V. D. Anderson Co. For twelve years prior to joining Anderson, Mr. Wright specialized in the development and special application of high efficiency purifiers as a consultant with a purifier manufacturer, practiced as a consulting mechanical engineer for 20 years and was at one time a staff engineer with Trundle Engineering Co. Mr. Odbert has had over 20 years of broad engineering experience, specializing for the last eleven years in fluid dynamics and the application of purifiers. Mr. Toth has ten years of engineering experience, four of which were as assistant to the chief engineer of a purifier manufacturer.

♦

Several new appointments were announced recently at the Boston Works of Allis-Chalmers Mfg. Co. **Leonard J. Linde** has been appointed general manager and chief engineer; **Henry P. Pinkham,** assistant chief engineer, and **John F. Chipman,** product engineer.

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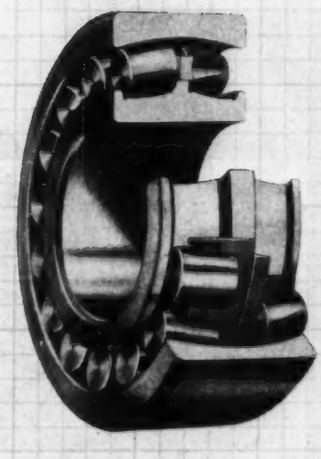

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ENGINEERS' LIBRARY

Analysis of the Four Bar Linkage

By John A. Hrones, professor of mechanical engineering, and George L. Nelson, assistant professor of mechanical engineering, both at Massachusetts Institute of Technology; copublished by John Wiley and Sons, Inc., New York, and Technology Press of MIT; 730 pages, 11⅛ by 17¼ inches, clothbound; available through MACHINE DESIGN, *$15.00 postpaid.*

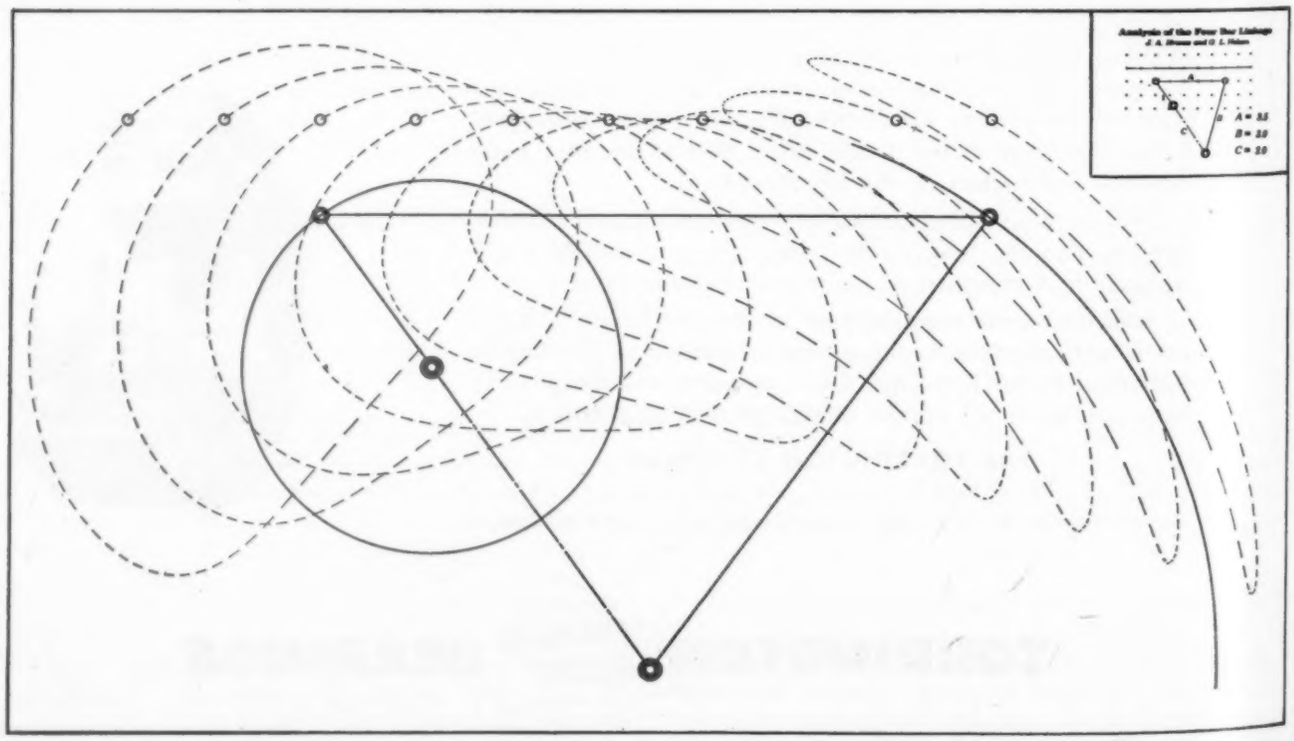
Difficulties in analysis and synthesis of four-bar linkages have frequently hindered their application in many designs where they could offer significant advantage. Although the four-bar linkage is one of the simplest of mechanisms, the equations which describe displacement, velocity, and acceleration of points on the connecting rod are both unwieldy and tedious to use. The alternate cut-and-try approach is often terminated before the best design is reached. As one practical answer to this problem, the authors of this giant-size volume give an index to four-bar linkage characteristics in the form of an extensive atlas of displacement trajectories. One of the 730 pages of charts is shown at 40 per cent actual size in the accompanying illustration.

All charts are for the range of operation where the driving crank makes a complete revolution while the follower crank oscillates. The series includes a wide range of link length ratios and of point locations on the connecting rod. Totaling more than 7000, the curves are classified according to a systematic arrangement of selected ratios and point locations.

Each trajectory consists of 72 dashes. Distance between corresponding points of adjacent dashes represents a 5-degree angular displacement of the driving crank. Average velocity and acceleration at any point on the trajectory can thus be determined from measurements of successive dash lengths.

By comparing the desired trajectory with the trajectories given in the charts, a designer should be able to determine quickly whether a four-bar linkage will meet his requirements.

The book also includes a short introductory text



Solve the problem of how to design automatic lubrication into machines where space is limited

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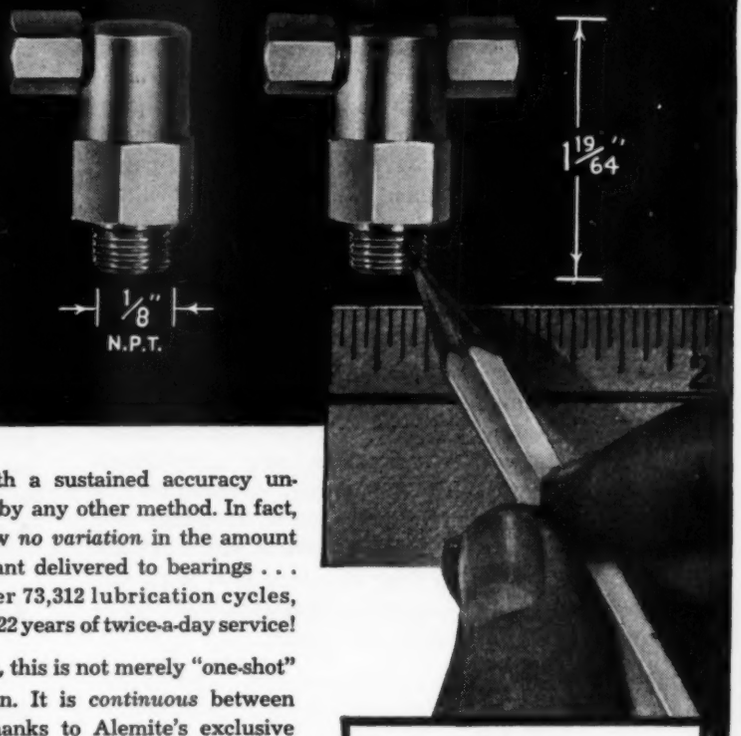


Tiny, simple, accurate . . . Alemite Midget Accumeter Valves make it easy to design automatic lubrication into small machines, precision machines, *any* machine having many small bearings concentrated in a limited space!

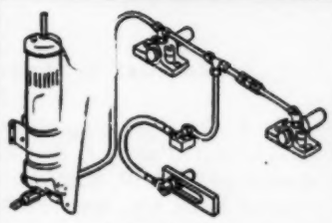
A Midget Accumeter System consists of a lubricant pump, a distribution system of tubing, and *force-feed* valves mounted on or near individual bearings. From one central point, it automatically oils all the bearings on a machine . . . *while production continues!*

Increases machine output by eliminating shutdown for lubrication. Ends the danger of errors or neglect by your customers. Makes your machines run better, cost less to maintain, last longer!

Alemite Accumeter Valves meter lubricants with a sustained accuracy unequalled by any other method. In fact, tests show *no variation* in the amount of lubricant delivered to bearings . . . even after 73,312 lubrication cycles, equal to 122 years of twice-a-day service!

Moreover, this is not merely "one-shot" lubrication. It is *continuous* between cycles, thanks to Alemite's exclusive "accumulating" feature that prolongs the discharge of lubricant to bearings!

Alemite Accumeter Automatic Lubrication is adaptable to machines of virtually every type and size. There are three different systems, to cover your full range of requirements. Write now for free bulletin giving full data. Alemite, Dept. R-81, 1850 Diversey Pkwy., Chicago 14, Illinois.



Serve Bearings of Any Type

Type O Midget Accumeter Valves can meter oil to rotary, oscillating, stationary—plain or anti-friction bearings. Up to 200 small bearings can be served by a single line system equipped with these *fixed output* valves. Require only 9/16" approximate turning radius.

ALEMITE

ACCUMETER AUTOMATIC LUBRICATION
1850 Diversey Parkway, Chicago 14, Illinois

Another Product of STEWART WARNER

which discusses fundamentals of the four-bar linkage and presents in detail several problem solutions based on the charts. A summary of the relative performance advantages of cams and linkages is included.

□ □ □

Illustrating for Tomorrow's Production

By J. Harold Farmer, director student union, North Texas State College, Abbott J. Hoecker, director creative department, Stafford-Lowdon Co., and Francis F. Vavrin, artist, Advertising Artists Studio; published by the Macmillan Co., New York, N. Y.; 203 pages, 6 by 9¼ inches, clothbound; available through MACHINE DESIGN, *$5.00 postpaid.*

In many plants the use of production illustrations, as distinguished from the standard top, front and side views of orthographic projection, is growing in importance. Pictorial representation of parts, products, assemblies and production operations is used in manufacturing, training and visualization of design problems, as well as illustrating printed catalogs, literature and service manuals. Considering this trend, the authors have presented a wide variety of methods and techniques for production illustrations, and have illustrated the book with 147 plates, many full-page. Although primarily designed for artists and illustrators in mechanical fields, this book contains much of value to engineers interested in this growing subject.

Isometric, oblique, true-scale perspective and exploded drawings are covered in the first four chapters. Mechanical methods for developing true perspective drawings and exploded views are given. After two chapters on fundamentals of illustrative and freehand drawing, production illustrations are considered. Rough and comprehensive layouts, techniques of rendering, presentation, reproduction of drawings and continuity of drawings are reviewed in the next six chapters. The remaining four chapters deal with aircraft illustration and production illustration in industrial advertising and industrial design.

□ □ □

Introduction to Mechanical Design

By T. B. Jefferson, editor, The Welding Engineer, *and Walter J. Brooking, special projects department, M. W. Kellogg Co.; published by the Ronald Press Co., New York; 612 pages, 6 by 9 inches, clothbound; available through* MACHINE DESIGN, *$6.50 postpaid.*

According to the preface, this textbook "approaches the subject as a whole in the light of functional purposes of a machine, its configuration requirements, economic considerations, the use of rational and empirical design data, and desired final appearance . . ." It was awarded the James F. Lincoln Arc Welding Foundation's first award in the machine design division of the Competitive Program for Modernized Textbooks. Although emphasis is placed strongly on welding as a process, extensive consideration is given to the other aspects of machine design.

After two chapters on machine types and functions, fundamental concepts and terminology, the book considers engineering materials and metalworking manufacturing processes. Fastenings and connections are covered in the next two chapters, with a chapter on the machine frame following.

Shafting and power transmission are discussed in a five-chapter section of the book. This section includes shafting, keys and couplings; bearings and lubrication; friction gearing, brakes and clutches; gears and flywheels; and belt, rope and chain drives.

Three chapters cover cams and linkages; springs; and piping and containers. Styling and the standardizing of machine elements are discussed in the final chapters.

□ □ □

Materials Handbook

By George S. Brady; published by McGraw-Hill Book Co., New York; 913 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$8.50 postpaid.*

Expanded to include almost 1500 more materials listings than previous editions, this seventh edition of the handbook contains information on over 8,800 materials. Part I, 796 pages long, gives pertinent physical and chemical properties, describes substitute and alternate materials, and lists patented and trade names. Part II provides economic and geographic information on materials and gives a great deal of miscellaneous data, such as fundamental nomenclature for materials used in various industries, definitions, weight and measurements tables, and tables of comparative characteristics of various materials.

Association Publications

Engineering Standards for Multiple V-Belt Drives: Recommended standards for multiple V-belt drives, V-belts and V-belt sheaves used primarily for industrial power transmission are established. Groove dimensions and standard keyseats for sheaves, V-belt cross-sections, pitch lengths and measuring tensions, and special factors for consideration in quarter-turn drives are all covered. Prime mover characteristics and suggested service factors for various applications are given. Recommendations are made for V-belt sizes for required horsepower ratings, and horsepower ratings for standard A, B, C, D and E-section V-belts. Formulas for center distance and belt length, and a table of takeup allowances are also included.

Copies of the 16-page manual may be obtained either from the Multiple V-Belt Drive Association, 7 West Madison St., Chicago 2, Ill., or the Rubber Manufacturers Association, 444 Madison Ave., New York 22, N. Y. Price is $0.50 per copy.

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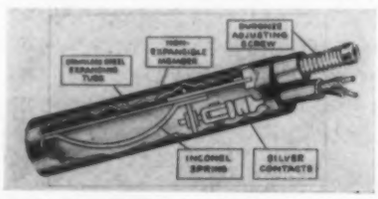
Chicago	Houston†	Newark	Rochester†	(†sales office only)
Cincinnati	Indianapolis	New Orleans	St. Louis	

NEW PARTS AND MATERIALS

. . . presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 189

Expanding Tube Thermostat 1

Smith Control & Instrument Corp., Palmyra, N. J.



Designation: Scaico Series 12, Series 58.

Style: Adjustable; expanding tube; single-pole, single-throw switch.

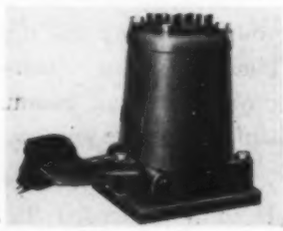
Size and Service: For controlling temperatures up to 600 F; made in 3 types for conduction, convection or immersion; series 12, ⅛-in. diam x 2⅜ in. long for 600 w loads, sensitivity 0.2 F on 1 amp load; series 58, ⅝-in. diam x 3 in. long for 1000 w loads, sensitivity 1 F on 1 amp load; both for 110 or 230 v a-c or d-c.

Design: Stainless steel tube expanding member; Invar strip nonexpanding member; Inconel spring for fast make and break switch action; Duronze adjusting screw to set control point; silver switch contacts provide two breaks in series; leads, supplied in desired length, are easily replaced.

For more data circle MD 1, Page 189

Foot-Operated Valve 2

C. B. Hunt & Son, Inc., 2200 E. Pershing Ave., Salem, Ohio



Designation: Quick-As-Wink.

Style: Foot operated; sliding sleeve type.

Size: ⅜ to 1 in.

Service: Air to 150 psi, 150 F; 3 or 4 way operation; on, off, neutral or exhaust positions.

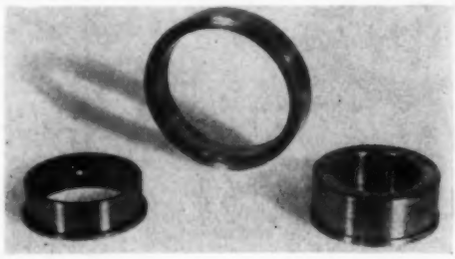
Design: Sliding sleeve valving mechanism with stainless steel body and push-pull rods, brass sleeves; cast iron housing; operating parts in pressure balance; pipe connections through top of housing; automatic return actions, single or two-pedal designs available; valve sleeve rides on flexible U-shaped packers which increase seal pressure as air pressure increases.

Application: Air-operated hammers, shears, presses, hopper gates, furnace doors.

For more data circle MD 2, Page 189

Steel-Backed Bronze Bearings 3

Beauideal Inc., 867 S. Water St., Saginaw, Mich.



Style: Sleeve.

Size: 1 to 8 in. diam sleeve; to 12 in. long.

Service: Heavy-duty or high-temperature, radial or thrust.

Design: Bronze bonded by nonmechanical process to inside or outside diameter of bearings; extrusion under heavy load is minimized; no separation between bronze and steel when bearing cut, straightened and twisted until bronze checks; with Nitralloy steel and high-leaded bronze bearing surface, can be heat-treated to 1100-1200 F., using long-grain bronze to 1500-1600 F.

Application: Airplanes, tanks, heavy-duty industrial

For more data circle MD 3, Page 189

Air and Gas Filter 4

Selas Corp. of America, Philadelphia 34, Pa.

Designation: Liqui-jector, Series B.

Style: Porous filter; continuous automatic liquid ejection.

Size and Service: Removes water, oil, water-oil emulsions and dirt as fine as 100 microns (0.004 in.) diam; automatically ejects liquids through compressed air trap; inlet pressures to 150 psi;

Model	Free Air Capacity (cfm)	Size (height x diam, in.)	Ports (Pipe size, in.)
B-10	100	19¼ x 9	1
B-25	250	20½ x 10	2
B-50	500	24 x 13½	2½

Design: Filter elements removable for cleaning; welded steel casing; male inlet at side, female at top, female drain at bottom.

Application: For pneumatically-operated machine and instruments systems.

For more data circle MD 4, Page 189

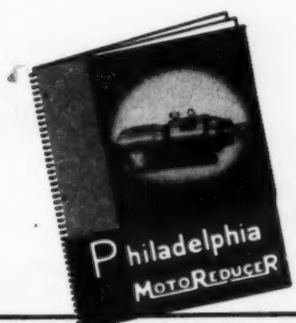
Instant PROTECTION ⇩ Against overload

The PlaneTorque is a feature that can be supplied with any Philadelphia MotoReduceR *(combined motor and speed reducer)* or Philadelphia Planetary Reducer to protect both the driven machinery and the drive unit from dangerous overloads.

By direct mechanical action of the overload, motor current is *automatically and instantly cut off* when a pre-determined limit is reached. This action is quicker than electrical thermal relays provide. (With fuse protection only, fuses must be selected to carry the starting current of the motor; therefore, protection during running period is *not adequate*.)

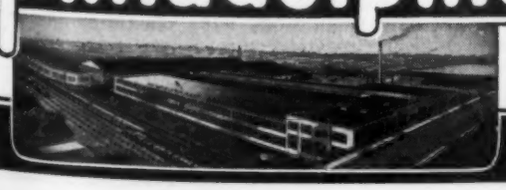
The PlaneTorque can be cut-out during the starting period by merely holding down the starting button, but will become operative during running period when button is released. To re-start the PlaneTorque MotoReduceR after overload cut-off, *only removal of excessive load is necessary . . . a big time-saving feature.*

For applications such as stoker drives, conveyor drives, mixers, agitators, roll drives, etc. . . . investigate the PlaneTorque MotoReduceR.



Send for Catalog MR-49, and please use your Business Letterhead when writing.

Philadelphia Gear Works, INC.



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Industrial Gears and Speed Reducers
LimiTorque Valve Controls

NEW PARTS AND MATERIALS

Foot Switch 5

Simonds Machine Co. Inc., 246 Worcester St., Southbridge, Mass.

Designation: Linemaster Lectro-Lok L-2-S.

Style: Treadle-operated; two independent SPDT electrical circuits with mechanical interlock.

Size: Approximately 5⅛-in. long by 2⅛-in. wide; weight 10 oz.

Service: Independently opens or closes one of two electrical circuits; rated 20 amp at 125 v or 15 amp at 250 v a-c only; mechanical interlock prevents simultaneous operation of both circuits; each circuit can be wired normally-open or normally-closed.

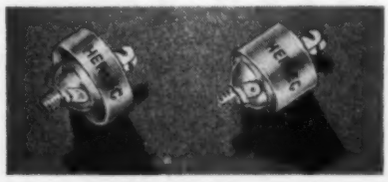
Design: Foot pressure on one side opens or closes line; release returns switch to normal off position; pressure on other side opens or closes second circuit; single cord receptacle with connections made internally; stamped metal housing; black crackle finish; other electrical combinations and special cord-sets available.

Application: Sound transmission equipment, appliances, intercommunication systems.

For more data circle MD 5, Page 189

Ceramic Capacitors 7

Herlec Corp., 422 N. 5th St., Milwaukee 3, Wis.



Designation: Sprague-Herlec.

Style: Ceramic dielectric, hermetically sealed in metal cup.

Size: ¾ or $\frac{11}{16}$-in. diam; height of case ¾ or $\frac{11}{16}$-in. max (case height depends on capacitance), with $\frac{5}{16}$-in. extension 6-32 externally threaded stud, or $\frac{5}{16}$-in. extension 6-32 internally threaded stud respectively; single solder-lug terminal—$\frac{27}{64}$-in. extension, double—$\frac{5}{16}$-in.

Service: Rigid frequency control; ¾-in. diam size rated 500 v d-c, $\frac{11}{16}$-in. size rated 500, 1000, or 1500 v d-c; capacitance tolerance can be controlled to within ±1%, temperature coefficient tolerance with ±10 parts per million; low self-inductance; hermetically sealed to exclude atmospheric humidity.

Design: Ceramic dielectric disks with silver electrodes fired on; stacks impregnated, then hermetically sealed in plated metal shell; ground solder-lugs available.

Application: Tank capacitors in oscillator circuits, laboratory and electronic circuit reference capacitance standards.

For more data circle MD 7, Page 189

Immersion Thermostat 6

Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass.

Designation: C4371.

Style: Snap action disk type; sealed for liquid immersion.

Size: 2⅝-in. long x $1\frac{5}{16}$-in. hex; ⅛-in. binding head extensions; 1 in. diam 11½ NPT male thread for mounting.

Service: Temperature control of liquids where external surface temperatures do not follow internal liquid temperatures closely enough; switch can be single or double-throw, single-pole, rating 10 amp at 30 v d-c and 125 v a-c, 8 amp at 250 v a-c; fixed temperature settings are factory preset; differential between opening and closing temperatures as needed from 15 F up.

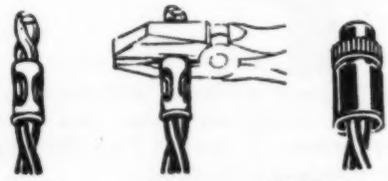
Design: Disk housing solder sealed on end of bronze body casting; fine silver switch contacts mounted on molded insulator; beryllium copper spring switch arm.

Application: Coolant and lubricant systems on engines and transmissions for military and industrial equipment.

For more data circle MD 6, Page 189

Wire Connector 8

Buchanan Electrical Products Corp., Hillside, N. J.



Designation: pres-SURE-connector.

Style: Open-end tubular metal splice cap with push-on plastic insulator.

Size: Number 2004S cap and 2005 insulator for two No. 18 to three No. 12 wires; number 2011S cap and 2012 insulator for three No. 12 to three No. 8 wire.

Service: For mechanically splicing two or three wires; pressure crimped on 4 sides for high strength; smooth bell-mouthed wire openings resist abrasion; approved by Underwriters Laboratories and Canadian Standards Assn.

Design: Twisted wires are inserted in upper splice cap to point where insulation touches cap; cap is then crimped at four places by special tool, and ends of wires are cut flush with cap; plastic insulator is pushed on over cap and encircling red ring pushed up to lock insulator on connection.

For more data circle MD 8, Page 189

NEW PARTS AND MATERIALS

Timing Motor 9

Bristol Motor Co., 310 *Bristol Bldg., Old Saybrook, Conn.*

Designation: Model 425.

Style: Miniature synchronous.

Size: 2-in. diameter x 1 13/64-in. depth; shaft extensions, in., 1/8, 0.375, 0.238, 0.125, 0.187; diameters, in., 0.100 plain or knurled, 0.125 plain, 0.100 plain or knurled, 0.125 plain or with 0.100-in. thread, 0.187 with 0.100-in. thread respectively.

Service: Synchronous timing from 1/6 to 60 rpm standard, 1/60 to 1800 rpm special; for 25, 115 or 230 (standard) v, 50 or 60 cycles; 110 v, 400 cycles;

Shaft Speed (rpm at 60 cycles)	Starting Torque (in.-oz at 115 v)	Shaft Speed (rpm at 60 cycles)	Starting Torque (in.-oz at 115 v)
1/6	75	5	3.3
1/5	72	6	3.1
1	16	10	1.8
2	8	20	0.9
3	5	25	0.7
3.6	4.3	30	0.6
4	4.0	60	0.2

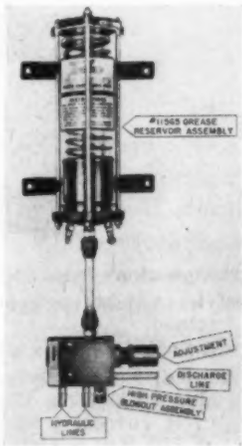
Design: Clockwise or counterclockwise rotation; special shafts can be furnished.

Application: running time meters, automatic, cycle and impulse timers, radio timers, aircraft instruments.

For more data circle MD 9, Page 189

Automatic Lubricator 10

Trabon Engineering Corp., 1814 *E. 40th St., Cleveland 3, O.*



Designation: Hydra - Lube HL-25.

Style: Hydraulic; automatic; oil or grease.

Size: Pump—3-in. high by 4 33/64-in. wide plus 3¾ max adjustment cap extension; all connections for ¼-in. pipe except lubricant inlet for ⅜-in. pipe; 3.5 or 12-lb. reservoirs, 4⅜ to 8 in. diameter by 15¾ to 16¾-in. length.

Service: Pumping oil or grease through automatic lubricating lines; capacity adjustable from 0.10 cu in. per stroke min to 0.25 cu in. max; 0.8 cu in. hydraulic oil required per stroke; lubricant pressure 3 times hydraulic pressure.

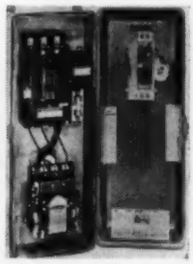
Design: Driven from hydraulic lines of any double-acting cylinder; each stroke of cylinder cycles pump once; grease reservoirs spring-loaded and sealed, mount in any position; oil reservoirs mount vertically above pump; safety blowout disk perforates when excessive pressure is developed in lubricating system; pressure gage and high pressure blowout switch assembly can be supplied; standard Trabon manifold feeder for distribution.

Application: Machine tools, presses, mining machines, production equipment.

For more data circle MD 10, Page 189

A-C Motor Starter 11

Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.



Designation: Class 11-206-NJ.

Style: Combination a-c motor starter and circuit breaker with thermal overload relay; three wire.

Size and Service: NEMA size 1 through 5, type 12 enclosure; across-the-line starting of squirrel cage motors or as primary switches for wound rotor motors; ratings up to 200 hp, 440 v, polyphase; meets JIC electrical standards for industrial equipment and machine tool electrical specifications as modified by mass production industry electrical specifications; 110 v fused secondary control circuit transformer operates from 220/440 v, 50 or 60 cycle line voltage.

Design: Double break silver contacts; arc quencher of parallel metal plates which divide and extinguish arc; bimetallic disk snap type thermal overload relay; three electrical interlocks (total of four) can be added; moving element of inverted clapper type armature balanced on knife edge with hardened steel bearing for easy operation; enclosure has neoprene gasket, is mounted on external brackets; handle must be moved beyond off position to open cover.

For more data circle MD 11, Page 189

Surge Damping Valve 12

Denison Engineering Co., Columbus 16, Ohio

Style: Normally-closed hydraulic spool valve, acceleration and differential pressure responsive.

Size:

Model	Length (in.)	Hex (in.)
T-4	4⅛	1⅝
T-6	4⅛	1⅝
T-8	4 1/16	1⅝
T-10	4½	1⅝
P-8	5	1⅞
P-16	5⅞	2⅛

Note: T denotes tube nose connections in accordance with AN specifications; P denotes female pipe connections; model number indicates tube and pipe size in 1/16-inches.

Service: Damping of surge pressures and vibrations in hydraulic systems; models T-4 through T-10 for up to 3000 psi, models P-8 and P-16 up to 5000 psi; sensitive to instantaneous reversals in pressure flow —gradually accelerates or decelerates flow in presence of surge; opens at slower rate of speed at high pressures than at low; rate of flow increases as differential pressure across valve equalizes.

Design: Spool valve, normally closed by spring, opens when pressure applied to inlet; rate of spool movement is controlled by pressure-responsive valve sensitive to difference between inlet and outlet pressures.

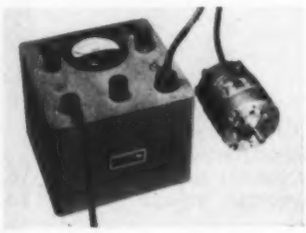
Application: As automatic decompression valves in cylinder circuits; in reversing circuits or accumulator lines of aircraft and industrial hydraulic systems.

For more data circle MD 12, Page 189

NEW PARTS AND MATERIALS

Motor and Control 13

Industrial Control Co., Straight Path Rd., Wyandanch, N. Y.



Designation: 301-A.

Style Package electronic control with separate d-c motor.

Size: Control box 7-in. square x 6-in. high; weight 6 lb.

Service: Controlled speeds from 0 to 5000 rpm; motor delivers up to 10 in.-oz torque from 50 to 5000 rpm; operates from 115 v, 60 cycle line; speed maintained at constant value regardless of load variation up to max torque.

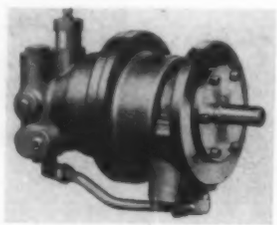
Design: For constant speed, voltage from armature of motor is fed back to grid circuit of a thyratron to control power input; speed adjustment knob on control box; front panel meter indicates motor speed in rpm; motor suitable for flange or base mounting.

Application: Conveyors, coil winding machines, textile spinning and weaving machines, controlling feed rates and cutting and grinding speeds on machine tools: driving segmented disks, synchronous switches, rotating antennas and laboratory data devices.

For more data circle MD 13, Page 189

High-Pressure Oil Pump 14

Oilgear Co., 1568-A W. Pierce St., Milwaukee 4, Wis.



Designation: HG-530, HG-830, HG-850.

Style: Integral axial piston pump and gear pump; fixed-stroke type.

Size: 13-in. long x 7-in. wide x 10-in. high.

Service: High-pressure, constant-delivery, one-direction pumping; operates at drive shaft speeds up to 1800 rpm, 3 to 15 hp input; 135 cu in. per min excess oil at 100 psi available for auxiliary purposes; volume delivered varies directly with drive shaft speed;

Model	Max Pressure (psi)	Capacity (cu in. per min at max pressure)
HG-530	3000	233 to 620
HG-830	3000	410 to 1090
HG-850	5000	204 to 580

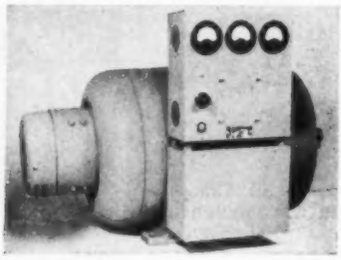
Design: Axial rolling-piston pump, supercharging gear pump, gear pump relief, valve and reverse-flow type high-pressure relief valve; pressure and flood lubricated by system oil.

Application: Heavy-duty pushing, pulling, lifting, lowering hydraulic circuits; maintaining high static loads on large clamping rams.

For more data circle MD 14, Page 189

High-Frequency Generator 15

Kato Engineering Co., 1415 First Ave., Mankato, Minn.



Style: Revolving field type.

Size: 49-in. long x 21½-in. wide without box or cabinet; weight 1325 lb.

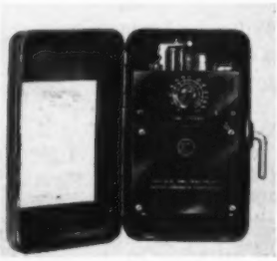
Service: Generates 75 kva of 400-cycle alternating current at 1714 rpm; available in single-phase or three-phase, generally 110/220 v on single phase, and 120 v single-phase plus 208 v three-phase on three-phase, four-wire models; frequencies from 300 to 500 cycles available by winding and operating speed changes; generators designed for inherent regulation give 8 to 10% regulation with noninductive load if generator speed held within 3%.

Design: Field coils energized from 125 v d-c exciter mounted on collector ring end-bell of alternator and driven by alternator shaft extension; main alternator shaft rotates on prelubricated ball bearings; available with engine, squirrel-cage motor or three-phase a-c motor drive; variable-frequency designs available.

For more data circle MD 15, Page 189

Short-Interval Timer 16

Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.



Designation: Type 30CR3.

Style: Adjustable nonsynchronous; electronic; self-contained.

Size: 9⅝-in. high x 6¾-in. wide x 4 7/16-in. deep.

Service: Accurately controlled timing intervals adjustable from 3 to 120 cycles (1/20 to 2 sec with 60-cycle current); accuracy within 2%; rating 10 amp at 115 v or 5 amp at 230 v, 50 to 60 cycle a-c, noninductive; draws 25 watts; SPDT switch; ambient conditions, 32 to 150 F temperature, 20 to 95% relative humidity; conforms with NEMA specifications for class 1A nonsynchronous timers.

Design: Control from momentary or sustained-contact switch by selection of proper terminals; terminal panel mounted behind bakelite dead-front; timing adjustment mounted inside housing.

Application: Punch press, machine tool and conveyor control; automatic filling operations in food and drug industries; manual, air or motor-operated welding equipment; control of squeeze, heat, cool, etc. times on resistance welders when used in combination.

For more data circle MD 16, Page 189

What's U.S. Rubber doing to make mechanical equipment more efficient?

THIS IS THE LABORATORY in the great U.S. Rubber plant at Fort Wayne, Indiana. Here engineers work out problems involving rubber-bonded-to-metal parts and all-rubber products.

RESULTS OF TESTS showing strength of Adhesion to Metal in U.S. Rubber Mountings. The mounting in the middle shows the original shape of the 2 adjacent mountings which have been "pulled" in a lab test. Note how the metal was badly bent before the adhesion failed. The D-nuts were actually torn out by the testing machine.

In the great "U.S." laboratory at Fort Wayne, "U.S." technicians are constantly studying problems involving all types of mechanical equipment with moving parts. Among their long list of successes are U.S. Rubber Mountings, which isolate vibration, absorb impact and reduce transmitted noise on motor cars, trucks and industrial equipment.

In helping to make machines more functional, more comfortable, more safe, the "U.S." scientists have at their command the great "U.S." laboratory at Fort Wayne, one of the largest and most modern in existence. It contains the finest research and development facilities. Many of its tools and machines are unique – some were designed by the very technicians who use them. These experts and the great "U.S." laboratory are at your service.

SEND FOR YOUR COPIES of these free booklets. They contain valuable information for the manufacture of mechanical equipment with moving parts. Write to address below.

PRODUCT OF U.S. RUBBER — SERVING THROUGH SCIENCE

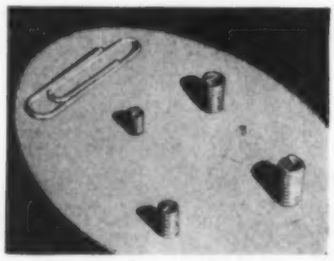
UNITED STATES RUBBER COMPANY

ENGINEERED RUBBER PRODUCTS • FORT WAYNE, INDIANA

NEW PARTS AND MATERIALS

Small Thread Inserts 17

Heli-Coil Corp., 47-23 35th St., Long Island City 1, N. Y.



Style: Small-size helical wire.

Size: 8-36, 6-40 fine thread; 5-40, 4-40 coarse thread; 1, 1½, 2-diameter lengths.

Service: Strengthening tapped threads; high loads on threaded holes possible; thread engagement over 90%; abrasion and corrosion-resistant; can be used in aluminum, magnesium, plastic, iron, steel, brass, bronze, wood.

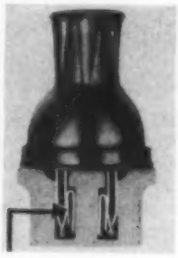
Design: 18-8 stainless steel shaped wire, helically formed.

Application: Assembly of appliances, business machines, automotive, aircraft and general manufacturing products.

For more data circle MD 17, Page 189

Electric Plugs 18

Laminated Metals Products Corp., 9993 Broad St., Detroit 4, Mich.



Designation: Waldron Spring-type.

Style: Double spring-type blades in conventional plug body.

Size: 1⅝-in. long (min) x 1-in. wide x $\frac{5}{16}$-in. thick for lamp cords; 1⅞-in. long (min) x 1-in. wide x ⅝-in. thick for heater cords.

Service: For electrical receptacle connection; rated 15 amp at 120 v or 10 amp at 220 v; hinged-joint spring-type blades insure connection in loose receptacle holes up to 0.100-in. wide; approved by UL.

Design: Flexible blades bowed out in both directions with spring-type hinge joint at outer edge of blade; blade halves spread apart to within ¼-in. of outer end; styrene plug body available in ivory, brown or white, furnished with plug blades welded to cordset wires and complete plug assembled to wires; replacement rubber-body plug (shown) also available with integral gripping handle and end-cavity insulating disk.

For more data circle MD 18, Page 189

Running-Time Meter 19

R. W. Cramer Co., Centerbrook, Conn.

Designation: HE2.

Style: Hermetically-sealed, synchronous-motor-operated mechanical register.

Size: 3½-in. diam face; 2.800-in. diam body x $2\frac{5}{16}$-in. deep plus $\frac{7}{16}$-in. terminal extension.

Service: Counting total time to 5 digits in 1/10-min, 1/10 hr or 1-hr increments; accuracy approximately 1/60-sec per operation; counter repeats after count of 99,999; hermetic sealing gives extended life span; power input 4.75 va, for a-c current; can register either running or idle time with proper relays; reset models can be returned to 0 at any time; meet Armed Forces specifications.

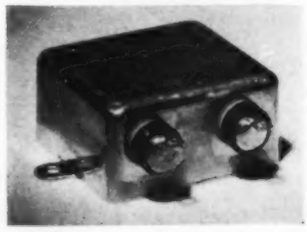
Design: Self-starting synchronous motor operates register through gear train; flush mounted.

Application: On automatic pumps and machines to record idle and operating time; vacuum tubes, process equipment, laboratory testing.

For more data circle MD 19, Page 189

D-C Capacitors 20

General Electric Co., Transformer and Allied Products Div., Pittsfield, Mass.



Designation: CP53.

Style: Fixed paper-dielectric, tinfoil.

Size and Service: Capacitance applications in accordance with "F" characteristics of JAN-C-25 for 100 v d-c units, or 150 v at 40 C temperature if expected life of 1000 hr is satisfactory; capacitance 105% rated value at −30 C to 93% at +100 C; full life expectancy at temperatures as low as −55 C; passes signal voltages approaching zero; permissible ripple voltages in accordance with section B-3a of JAN-C-25 (20% peak at 60 cycles, 15% at 120 cycles, 1% at 10,000 cycles) but will withstand occasional surges; 100% rating at altitudes to 50,000 ft.

Capacitance (microfarad)	Watt-Second Rating	Size (in.) width x depth x height
3	0.015	2⅛ x 1* x ⅝
8	0.04	2¾ x 2* x 2
10	0.05	2¾ x 2* x 2

* Plus $\frac{11}{16}$-in. front extension for solder-lug terminals.

Design: Thin paper, tinfoil capacitors with extended-foil construction; Pyranol treated; hermetically sealed in metal cases with bright hot-tin-dipped finish.

For more data circle MD 20, Page 189

ADVERTISEMENT

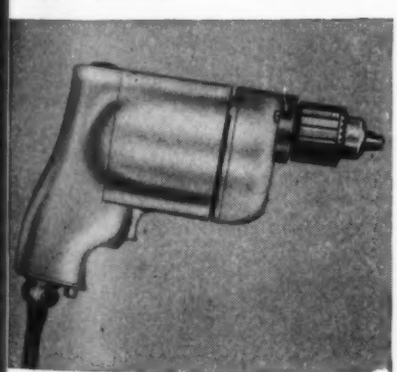
POWDER METALLURGY

PARTS EFFECT OPERATING SAVINGS

Cost-conscious users of production machinery are becoming increasingly aware of the over-all savings made possible in the operation of machines equipped with "COMPO" and "POWDIRON" bearings and parts. Maintenance expenses are reduced, since in many instances "COMPO" and "POWDIRON" need no re-lubrication during the life of the equipment. When more severe conditions do require re-oiling, the job is extremely simple—it is only necessary to bring oil into contact with the part. Even this simple attention is required only at infrequent intervals.

OTHER OPERATING SAVINGS

The "COMPO" and "POWDIRON" method of lubrication maintains an oil film on the surface of the bearing or part at all times, thus presenting metal-to-metal contact. This feature reduces wear and prevents scoring of shafts. Bearing replacement is a very rare occurrence, and machine downtime is greatly reduced.



Electric drills equipped with "COMPO" bearings run smoothly and quietly, with minimum maintenance requirements.

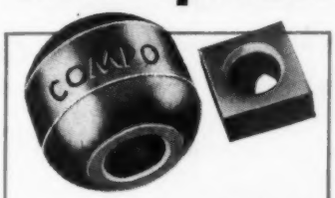
HOUSEHOLD AND BUSINESS APPLICATIONS

While the average user of household appliances or business machines is less aware of operating costs than the industrial executive, the long life and simple maintenance of "COMPO" and "POWDIRON" are important selling advantages in these types of products too.

The manufacturer can build these good-will features into his products at surprisingly low cost, since the powder metallurgy process is inherently economical, especially in high-volume runs. Information on "COMPO" and "POWDIRON" for specific applications may be obtained from Bound Brook Oil-Less Bearing Company, Bound Brook, N. J.

Low Operating and Maintenance Cost IS ONE OF THE 6* OUTSTANDING ADVANTAGES OF "COMPO"® and "POWDIRON"®

BEARINGS AND PARTS



*THE 6 OUTSTANDING ADVANTAGES OF

"COMPO" and "POWDIRON" are

1. Low operating and maintenance cost
2. Low installation cost
3. High load capacity at high speeds
4. Extreme quietness
5. Efficient lubrication
6. Low unit cost

Constantly maintained oil film keeps both *starting* and *running* friction down. Replacements are virtually nil — relubrication is simple, if needed! Incorporate "COMPO" and "POWDIRON" bearings and parts in *your* product designs — give your customers the cost-saving features they want.

Cut costs *yourself* by using stock "COMPO" bearings wherever possible — write on company letterhead for up-to-minute catalog.

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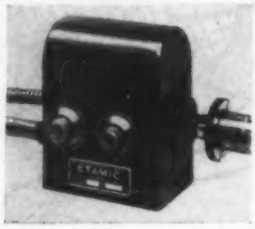
"COMPO" • "POWDIRON" • "BOUND BROOK"

Air Gage and Control 21

Ateliers de Normandie, 12 bis Place de Laborde, Paris 8, France



Designation: Etamic.

Style: Measurement-responsive package controls.

Service: Automatic gaging to 0.001-mm (0.00004-in.); control of two or more independent electrical circuits to indicate max and min, go or no-go, separation of parts into over, under and within-tolerance classes, etc.; operation in 0.01-sec; high-pressure air over 60 lb per sq in. cleans workpiece so that gage can be used simultaneously with operation of grinding machine, etc.; air consumption 106 cu ft per hr, line pressure 57 lb per sq in. min.

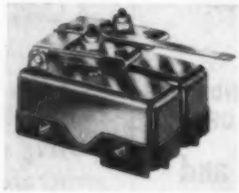
Design: High-pressure air supplied through gaging orifice and two or more calibration orifices with adjustable needle valves; as diameter of piece reaches desired dimension, air-pressure differential between gage tube and needle-valve tube causes manometric diaphragm located in bypass between tubes to operate electrical circuit; electrical contacts can be used to operate signal and/or machine.

Application: Various gaging heads available for use with external and internal cylindrical, and centerless grinders; calibration and control of wire or strip thickness; automatic sorting; multiple gaging on same workpiece.

For more data circle MD 21, Page 189

Ganged Precision Switches 22

Unimax Div., W. L. Maxson Corp., 460 West 34th St., New York 1, N. Y.



Designation: SAT-1-Z1.

Style: Double individually adjustable precision SPDT switch assembly.

Size: Body size $1\frac{13}{16}$-in. long x $1\frac{3}{8}$-in. wide x $\frac{13}{16}$-in. high; $\frac{9}{16}$-in. max leaf height, $\frac{5}{8}$-in. extension.

Service: Closing two circuits simultaneously or in desired sequence; operating point of switch adjustable $\frac{9}{32}$-in.; operating force 1.0 to 2.0 oz per switch; release force 0.5 to 2.0 oz per switch; movement differential 0.060-in. max; rating as follows:

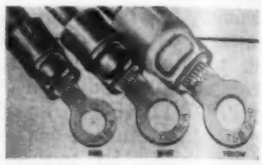
Volts	Heater Load (amp)	Lamp Load (amp)	Motor, Relay and Solenoid Load (amp)
110-125 a-c	15	3	10
220-250 a-c	5	1.8	5
6-8 d-c	20	5	8
12-14 d-c	20	5	5
24-30 d-c	2	2	1
110-115 d-c	0.4	0.4	0.03
220-230 d-c	0.2	0.2	0.02

Design: Allen head screw, with elastic type stop nut, adjusts point where U-spring bears on operating pin; contact separation 0.010-in. nominal; pretravel and overtravel provided; terminals—solder-lug, screw, screw with ear or front-facing screw with cup washers; leaf actuator in style specified, on either side of switch; two or more switches can be actuated in unison or sequence.

For more data circle MD 22, Page 189

Insulated Crimp-On Terminals 23

Thomas & Betts Co. Inc., 58-A Butler St., Elizabeth 1, N. J.



Designation: Sta-Kon.

Style: Integral assembly of tongue and barrel, bronze sleeve and insulating skirt.

Size: For AWG and AN wire sizes 22, 20, 18, 16, 14, in no. 6 and 10, $\frac{1}{4}$ and $\frac{3}{8}$-in. stud sizes; for AWG 12, 10, in no. 6, 10, $\frac{1}{4}$ and $\frac{3}{8}$-in. stud sizes.

Service: For maximum protection against short-circuit on closely-spaced terminals; insulation formulated to give dielectric strength (short time) of 385 v per mil; volume resistivity 4.5×10^{13} ohms per cm; power factor 0.014 at 60 cycles; longer electrical average path due to built-in air gap; grip on wire exceeds AN specifications; insulation remains stable at high temperatures, is slow-burning and self-extinguishing, withstands baking temperatures of standard insulating varnishes; insulation resists attack by hydraulic fluids, gasoline, naphtha, cleaning agents; approved by UL; meets Air Force-Navy specifications.

Design: Copper tongue and barrel, bronze sleeve and molded nylon insulating skirt press-fitted together and locked by flaring copper barrel; assembled on wire by crimping barrel on end of bare wire with special tool; color-coded in red, blue and yellow; wire size stamped on terminal.

Application: Instruments, control apparatus, electronic equipment, aircraft, appliances.

For more data circle MD 23, Page 189

Magnetic Contactor 24

R-B-M Div., Essex Wire Corp., Logansport, Ind.

Style: Magnetic; normally-open contacts.

Size $3\frac{5}{8}$-in. high x $3\frac{1}{16}$-in. deep; width depends on number of poles.

Service: For 25-amp duty, 600 v max, 25-60 cycles a-c; rating polyphase, 3 hp at 110 v, 5 hp at 208-220 v, $7\frac{1}{2}$ hp at 440/550 v; rating, single-phase, $1\frac{1}{2}$ hp at 110 v, 3 hp at 220 v, 5 hp at 440/550 v; 2 to 5 pole construction, reversing and nonreversing; normally-open contacts only; can be mounted directly on grounded surface.

Design: E-type magnet with floating armature; solderless terminal lugs for no. 6 wire standard, screw terminals special; steel base with neoprene mounting grommets; interchangeable with 10, 15 or 25-amp sizes with same number of poles; open or enclosed types; can be furnished with power poles and convertible interlocks.

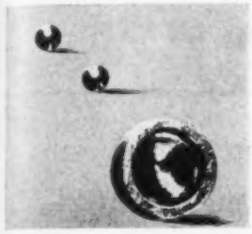
Application: Machine tools, electric hoists, overhead door operators.

For more data circle MD 24, Page 189

NEW PARTS

Miniature Ball Bearing 25

Miniature Precision Bearings Inc.
101 Carpenter St., Keene, N. H.



Style: Miniature pivot, ball.

Size: 1.5 mm OD; 1.2 mm wide; weight 0.019-gram.

Service: Antifriction bearings for relatively heavy loads under shock and vibration conditions; OD tolerance +0, −0.0002-in.; rating 0.29 lb at 1000 rpm thrust.

Design: Pivot shaft holds four 1/64-in. balls in place; raceway designed so that greatest mass is at point of greatest strain.

Application: Precision instruments, servomechanisms, gyros, textile rollers, fishing reels.

For more data circle MD 25, Page 189

Accordion Sleeve 26

A & A Mfg. Co., 2017 W. Clybourn, Milwaukee 3, Wis.

Designation: Gortite.

Style: Telescoping bellows sleeve.

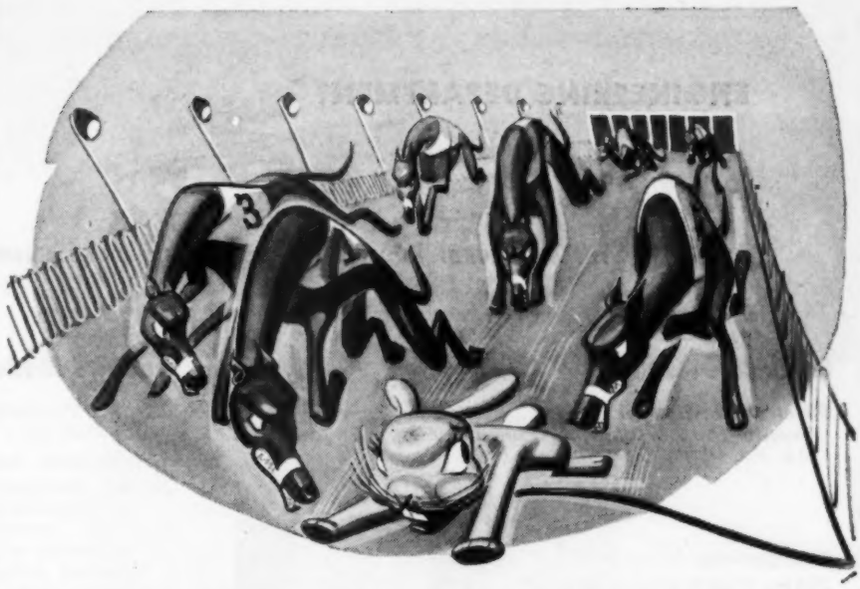
Size: From 1 in. ID x 2 in. OD to 12 in. ID x 24 in. OD; lengths 2 in. to 30 ft.

Service: Protecting working parts; impervious to oil and water; nonhygroscopic; compresses to fit irregular shapes; will not crack under temperature changes.

Design: Fabricated from high tensile strength neoprene-impregnated fabric of uniform thickness.

Application: Lead screws, hydraulic rams, slides, etc., on machines.

For more data circle MD 26, Page 189



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* This fable can be and has been acted upon to save the less expendable hides of some of the most able electrical maintenance engineers.

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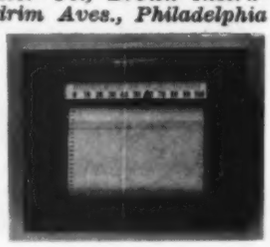
ENGINEERING DEPARTMENT

EQUIPMENT

For additional information on this new equipment, see Page 189

Function Plotter 27

Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Wayne & Windrim Aves., Philadelphia 44, Pa.



Designation: ElectroniK.

Style: Pen-marking with independent electrical circuits to control pen travel and chart movement.

Service: For plotting curves showing $y = (f)x$ for any two continuous related variables; pen traverse x controlled by one variable, chart movement up or down controlled by second y; available with full-scale 11-in. pen traverse in 24, 12, 4½ or 2 sec, full-scale 15-in. chart traverse in 24, 12 or 4 sec; dead zone 0.06% of span; furnished in two styles, one for d-c actuation of each variable, one for d-c pen actuation and selsyn-motor chart actuation.

Design: D-c actuation through null-balance servo system for each variable, selsyn motor can be used for chart drive with matching motor supplied by user; push-button starting; can be furnished with inductance bridge operation for pen, and auxiliary operations pen.

Application: Plotting speed vs. torque, stress vs. strain, engine speed vs. governor position, pressure vs. displacement, etc.

For more data circle MD 27, Page 189

Decade Inductor 28

Hycor Co. Inc., 11423 Vanowen St., N. Hollywood, Calif.

Designation: 700 Series.

Style: Toroidal coils with selector switch.

Size: 5¼-in. long x 3-in. wide x 2¼-in. high.

Service: Inductance over full range in 10 equal steps; tolerance 2%; good stability, low hum pickup; maximum inductance, type 700—0.010 h, type 701—0.1 h, type 702—1 h, type 703—10 h.

Type	Q Factor 1000 cycles	Q Factor 4500 cycles	Q Factor 20,000 cycles	Self-Resonant Frequency (cycles)
700	40	75	40*	150,000
701	60	125	60	60,000
702	60	125	60	21,000
703	60	125	..	5,400**

* 60 at 10,000 cycles. ** 15,000 in position 1.

Design: Five toroidal inductors connected in various series by 10-position (plus zero) rotary wafer-type selector switch; coils, nearly astatic to external magnetic fields, are impregnated with chemically inert wax and potted together.

Application: Design and experimental work on filter networks, equalizers, tuned circuits.

For more data circle MD 28, Page 189

Young's Modulus Tester 29

Electro Products Inc., 4501 N. Ravenswood Ave., Chicago 40, Ill.

Designation: Sonometer.

Style: Packaged oscillator, amplifier, and amplifier resonance indicator with separate mechanical driver unit and crystal pickup.

Size: 22 in. wide x 20 in. high x 15-in. deep.

Service: Determining Young's modulus by driving test sample into torsional or flexural vibration; use of special formula involving specimen weight, resonant frequency and factor depending on shape, size, mode of vibration and Poisson's ratio gives Young's modulus; oscillator frequency controllable from 20 to 20,000 cycles per sec; less than 2% drift; power controlled from fraction of watt to 18 w; 115 v, 60 cycle a-c operation.

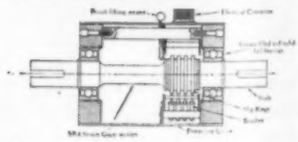
Design: Sufficient power fed to driver, placed at one end of sample, to vibrate sample under flexure or torsion; by tuning oscillator through frequency range, modes of vibration and resonant frequencies can be determined through pickup, amplifier resonance indicator and cathode-ray oscilloscope (not furnished.)

Application: Testing metal products, plastics, hood materials, concrete.

For more data circle MD 29, Page 189

Torque Meter 30

Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.



Designation: SR-4, Type A.

Style: Self-contained; resistance wire strain gage bonded to shaft; Wheatstone bridge circuit.

Size and Service: Max calibration inaccuracy ±¼%; 120% of rated torque causes no adverse effects; 150% causes small zero shift; mechanical or electrical failure at point in excess of 300% of rated torque; resistance across power input terminals at 70 F 350 ± 2 ohms, same across output; temperature limit 140 F; supply voltage up to 12 v a-c, max to 25 v a-c;

Type	Capacity (in.-lb)	Max Speed (rpm)	Length x Dia (in.)	Shaft (in.)
A-01	100	7000	11⅞ x 4⅞	0.500
A-02	200	7000	11⅞ x 4⅞	0.500
A-05	500	7000	11⅞ x 4⅞	0.875
A-1	1000	7000	11⅞ x 4⅞	0.875
A-2	2000	5000	15 x 5⅝	1.501
A-5	5000	5000	15 x 5⅝	1.501
A-12	12,000	5000*	19¾ x 7¾	2.501
A-30	30,000	5000*	19¾ x 7¾	2.501

* Water cooling for speeds above 3000 rpm.

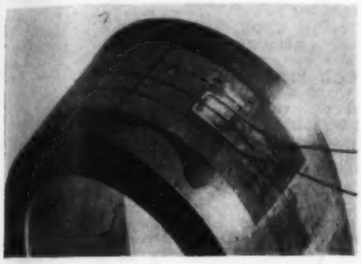
Design: Four arm Wheatstone bridge circuit, temperature compensated against variation of zero and output; slip rings on shaft and nonrotating brush assembly energize strain gage bridge; type A-12, A-30 have provisions for water cooling.

For more data circle MD 30, Page 189

ENGINEERING DEPT. EQUIPMENT

Strain Gage 31

Baldwin-Lima-Hamilton Corp., Eddystone Div., Philadelphia 42, Pa.



Designation: Type PA-3.

Style: Paper base, flat bonded wire grid.

Size: Gage length $\frac{13}{16}$-in., width $\frac{5}{16}$-in.; overall length $1\frac{7}{8}$ in., width $\frac{5}{16}$-in.; min trim width $\frac{13}{32}$-inch.

Service: Measuring strains up to 10%; gage factor 2.0; nominal resistance 120 ohms.

Design: Gaging element consists of cupro-nickel wire looped back and forth to form flat grid pattern and sandwiched between two thin-paper covers; special air-drying cement supplied.

For more data circle MD 31, Page 189

Drafting Table 32

Stacor Equipment Corp., 1891 Atlantic Ave., Brooklyn 33, N. Y.

Designation: EB6036B.

Style: 4-post steel with adjustable wood top.

Size: Board sizes 36 in. high x 60 in. wide; 36 in. high x 72 in. wide; 42 in. high x 72 in. wide.

Design: (1, 2) Steel 4-post base and foot rest; (3) two all steel adjusting devices to adjust board angle; (4) steel shallow reference drawer, 36 x 28 x 2 in; (5) steel tool drawer with lock, 2 keys and tool tray, 10 x 27 x 5 in; table available with both drawers, tool drawer only or without drawers; smooth finish kiln dried soft wood top; (7) pressed wood dust cover hard baked gray enamel finish.

For more data circle MD 32, Page 189

Check

R-B-M INDUSTRIAL CONTACTORS NOW!

Underwriters' Approved. 600 Volts AC

SIZE

Non-Reversing

2 to 4 Pole 2-3/4" w. x 3-5/8" h. x 3-5/16" d.
5 to 8 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.

Reversing

2 to 4 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.

Note: 10 and 15 ampere contactors have same mounting and overall dimensions.

ACCESSIBILITY

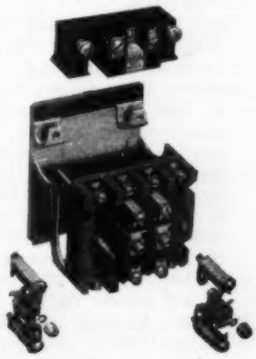
To replace contacts, it is not necessary to disassemble the complete contactor. Just remove the parts comprising the stationary and movable contacts. Contacts can be replaced without disturbing wiring. To change coil, remove magnet frame and coil assembly only. (See illustration below.)

FLEXIBILITY

Using a screw driver only, you can easily change any pole from normally open to normally closed. No special parts required. 10 and 15 ampere parts are interchangeable.

RELIABILITY

Laboratory tests involving millions of operations, plus field service of thousands of R-B-M contactors on door operators, radio transmitters, packaging and weighing machinery, hoists, machine tools and many other industrial applications offer proof of dependable, trouble-free performance.



ADVANCED DESIGN

Melamine Insulation. Molded coil housing. Ilsco solderless connectors. 50/60 cycle magnet coils. Palladium silver contacts. Stainless steel self-contained contact springs.

Where space is a factor, and accessibility a must—use R-B-M industrial contactors. Initial low cost plus dependable performance will save you money. Write for Bulletin 600 and price list on your company letterhead.

Address Dept. B-8

RBM

R-B-M DIVISION
ESSEX WIRE CORP.
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS
FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

Portable Tachograph 33

O. Zernickow Co., 15 Park Row, New York 7, N. Y.

Designation: G12, G24, G48.

Style: Recording pen mechanism attached to hand tachometer; portable.

Size: 10¾-in. long x 3¼-in. wide x 4½-in. high; 2¾-in. wide chart paper.

Service: Records rpm or fpm, speed fluctuations, accelerations and decelerations; five rpm speed ranges for each instrument—G12, 30-120, 100-400, 300-1200, 1000-4000, 3000-12,000—G24, 60-240, 200-800, 60-2400, 2000-8000, 6000-24,000—G48, 120-480, 400-1600, 1200-4800, 4000-16,000, 12,000-48,000; fpm speeds half of above values using 6-in. diam wheel supplied; two paper speeds provided, ¼-in. and ½-in. per sec; each speed range records over full paper width; accurate to within 0.5% at any reading; tachometer not affected by electricity, magnetism, temperature changes, moisture.

Design: Paper travel and timing mechanism operated by spring motor; disk-drawn horizontal lines correspond with dial divisions; vertical time division marks drawn at 1-sec intervals; tachograph damping accomplished with high-speed light wind vane with beryllium bearings; balanced tachograph mechanism has ground hard steel spindles, steel or bronze gears, cast aluminum alloy housing with anodized gear-shift cap and bezel ring.

For more data circle MD 33, Page 189

Recording Voltmeter 34

Bristol Co., Waterbury 20, Conn.

Designation: Series 500.

Style: Single-range moving-iron type automatic pen recorder; wall, surface or flush-panel mounting.

Size: Housing—14⅜ in. high x 10¾ in. wide x 5¾ in. deep; weight 17½ lb; 8 in. diam circular chart.

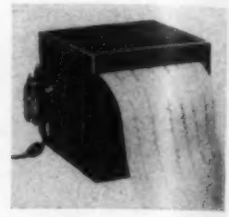
Service: Continuous record of voltage; accuracy ±1% of full scale value; chart rotation speeds—(with single-speed spring drive) 12 hr, 24 hr, 48 hr, 7 days—(with two-speed spring drive) 24 hr and 7 days, 48 hr and 7 days, 2 and 8 hr, 96 min and 24 hr, 15 min and 1 hr—(with electric drive) 30 min, 8, 12, 24, 48, 72 hr, 7, 30 days— (with electric and reserve spring drive) 24 hr or 7 days; records in 90-130 or 140 v range with 6.5 va load, 96.5% power factor, in 180-260 or 280 v range with 14 va load, 73.4% power factor.

Design: Moving-iron type actuating mechanism with eddy-current permanent magnet damper; die-cast corrosion-resistant aluminum case, moisture, fume and dust-proof; available with ½-in. conduit or insulated open terminal stud connections; stainless steel ball bearings, shockproof mounted; interchangeable spring, synchronous motor, or synchronous motor with reserve spring chart drive; case sealed with sponge-rubber gasket; portable, pole-mounted and double-range instruments available.

For more data circle MD 34, Page 189

High-Speed Recorder 35

Offner Electronics Inc., 5320 N. Kedzie Ave., Chicago 25, Ill.



Designation: Dynograph Recording Assembly.

Style: Direct pen writing high-speed oscillograph, chopper-type amplifier and power supply in three separate units.

Size: Three channels; oscillograph has provisions for total of ten; roll or folded paper to 12½ in. wide.

Service: High-speed pen recording of rapidly fluctuating data; pen response 1/120-second; sensitivity 150 mv d-c per cm pen deflection; linearity within 1% for total deflection of 4 cm, decreasing up to total deflection of 7 cm; paper speeds 0.5, 1, 2.5, 5, 10 and 25 cm per second through change-gears; stability attained through high a-c amplification of d-c input voltage; true differential input obtained by electrically isolating source from amplifier with input transformer coupling; reluctance type pickups may be used directly.

Design: D'Arsonval-type pen movement operating in strong magnetic field of approximately 10 kilogauss; high current through low (6 ohm) resistance coil gives strong torque on pens; restoring force supplied by heat-treated beryllium copper torsion rod with minimum hysteresis.

Application: Recording rapid transients, vibration, temperature, stress and strain.

For more data circle MD 35, Page 189

Translucent Reproduction Paper 36

Eastman Kodak Co., Industrial Photographic Div., Rochester 4, N. Y.

Designation: Kodagraph Autopositive Paper, Translucent.

Style: Translucent silver-sensitized photographic paper.

Size: 8 x 10, 8½ x 11, 8½ x 14, 9 x 12, 11 x 14 in. sheets in 100 or 500 sheet packages; 11 x 17, 12 x 18, 14 x 17, 17 x 22, 18 x 24, 20 x 24, 24 x 36 in. sheets in 50 or 250 sheet packages; 8½, 9, 12, 20 in. width rolls in 60, 100 or 250 ft lengths; 24, 30, 36, 42 in. width rolls in 30, 100, 250 ft lengths; special sizes available.

Service: Intermediate paper for reproduction of originals; direct-to-positive intermediate prints on standard reproduction equipment in ordinary room light; processed in standard photographic solutions; moistened lines erase with ordinary pencil eraser; detail can be read through back of paper; corrections can be made in pencil or pen.

Design: Silver emulsion on translucent paper base; Kodagraph Sheeting Yellow or Orange must be used as filter in front of light source.

Application: For making blueprints or direct-process prints from opaque originals, blueprints or direct-process prints.

For more data circle MD 36, Page 189

HELPFUL LITERATURE
FOR DESIGN EXECUTIVES

79. Roller Bearings

Shafer Bearing Corp.—Full line of industrial roller bearings and mounted units including pillow blocks; flange, flange cartridge, cartridge, duplex, take-up, and take-up and frame units; and unmounted roller bearings is described in 56-page illustrated catalog No. 51. Bearings feature concave rollers operating between matched convex races which assure self-alignment, high shock load capacity and low friction.

80. Valve Seal

Rodic Chemical & Rubber Corp.—12-page illustrated booklet presents Rand Seal principle that permits designing valves for handling slurries and similar process liquids that contain rust, sand or other abrasive contamination. Rubber component of this seal is of high quality synthetic rubber compounded for maximum resistance to oils, solvents, greases, steam and water.

81. Vibrationproof Fasteners

Shakeproof Inc.—24-page illustrated booklet "Assembly Suggestions" is made available to assist designers and product engineers in selection of fastenings best suited for specific requirements. Included is explanation of manufacturing facilities available at company and display of typical special defense products.

82. Bimetal Strip Thermostats

Stevens Mfg. Co.—Illustrated bulletin L-4079 describes type W bimetal strip thermostats for use in refrigerators, electronic and avionic devices, fans on rectifiers and industrial apparatus. Various terminal arrangements available in adjustable and nonadjustable styles, dimensional drawings, schematic diagrams of operating principle and typical response curve are included.

83. Industrial Products

Bendix Aviation Corp.—44-page illustrated brochure "Bendix and Your Business" gives details of engineering and production facilities of the many divisions of this company. Components made for agriculture, automotive, aviation, construction, electronic, military, marine, lumber, metalworking, petroleum, public service, railroad and textile fields are shown and detailed.

84. Stainless Pipe

Carpenter Steel Co., Alloy Tube Div.—Advantages of light walls that conserve critical alloys and reduce installation costs are outlined in data sheet "How You Can Get More Stainless Steel Pipe for Your Money" on Schedule 5 light weight stainless pipe. Technical data on wall thickness, pressures and strength are given.

85. Glass in Electric Products

Corning Glass Works—"Glass in the Design of Electrical Products" is title of 8-page illustrated bulletin No. B-88. In addition to presenting typical uses of glass in electronic and electric components, complete properties of various types of glass are tabulated for quick reference.

86. Metal Fabricating Facilities

Hupp Corp., Globe Stamping Div.—Complete equipment which is available for defense and subcontract work involving production stamping, metal fabricating and finishing is described in 12-page illustrated "Facilities Report." Companion 4-page illustrated bulletin lists 80 presses ranging from 1 to 350-ton capacity and other machines which are available for contract work.

87. Cushioning Materials

Sponge Rubber Products Co.—8-page illustrated booklet "Package Cushioning" outlines properties of Texlite rubberized hair and wool, Texfoam latex foam rubber, Spongex sponge rubber, Spongex Cell-Tite unicellular rubber and Spongex Plastic No. 1 unicellular plastic. Properties and uses are described.

88. Oil Purifiers

Honan-Crane Corp.—Savings effected through use of oil purification equipment for hydraulic, quenching and cutting oils and coolants are cited in 4-page illustrated bulletin. Case studies are presented on oil purification for presses, molding machines and machine tools.

89. Electric Motors

Wagner Electric Corp.—General information regarding available sizes of capacitor start and repulsion start single phase induction motors and polyphase motors in open type squirrel-cage, explosionproof totally enclosed, cast iron frame and fan cooled models is presented in 4-page illustrated bulletin MU-94.

90. Strain Gages

Baldwin-Lima-Hamilton Corp.—Descriptions and specifications of SR-4 Post-Yield resistance wire strain gage, suitable for strains up to 10 per cent, are given in illustrated bulletin 322.

91. Design Facilities

Sola Electric Co.—24-page illustrated booklet describes research, design and production facilities of company. Emphasis is placed on expansion since end of World War II. Company makes constant voltage, lighting and wide variety of specialty air-cooled transformers.

92. Plastic-Surfaced Plywood

Douglas Fir Plywood Association—Issued as reference manual, this catalog folder describes plastic-surfaced plywood. Types available, properties of overlay panels and possible applications in building and industry are illustrated. Also included are recommendations for use of premium-surface panel material.

93. Wire Cloth & Screen

Cambridge Wire Cloth Co.—4-page illustrated bulletin No. 87 gives available weaves and mesh sizes of woven wire cloth, wire screen and filter cloth for special applications.

94. Dynamometers

General Electric Co.—Details on 250-v dc dynamometers for direct-connection testing of internal combustion engines, electric motors, pumps, blowers and compressors are described in 4-page illustrated bulletin GEA-5552. Included is table of full-load horsepower and speed ratings and chart showing typical performance curves.

95. O-Rings

Arrowhead Rubber Co.—8-page illustrated catalog No. 502B presents engineering information and data on design for proper installation of O-rings. Gland groove design information and O-ring and gland groove dimensions are included.

96. Leather Belting

E. F. Houghton & Co.—Practical maintenance suggestions as well as complete engineering data are included in 16-page illustrated bulletin "Houghton's Treaded Leather Belting". Belt formulas, horsepower ratings of various size shaftings at various speeds, procedure for making belts endless on pulleys, types of motor bases and other information are presented.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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97. Centrifugal Castings

Shenango-Penn Mold Co., Centrifugal Castings Div.—Range of component machine parts and assemblies produced by centrifugal casting method is subject of two illustrated bulletins. No. 150 covers nonferrous metal parts including bronzes, Monel metal, nickel, aluminum and special alloys, while No. 151 features parts of Meehanite metal, Ni-Resist and special iron alloys.

98. Woven Wire Conveyor Belts

Korb-Pettit Wire Fabrics & Iron Works Inc. —40-page illustrated catalog No. 31 contains specifications and detailed descriptions of standard and special wire conveyor belting weaves. Power formulas and construction details are included, as are suggestions for prolonging belt life and increasing efficiency.

99. Steel Tubing

Brainard Steel Co., Tubing Div.—8-page illustrated booklet shows fabrication and typical application of welded mechanical and structural steel tubing. Tabular data on weights per linear foot plus size and gage tolerances for both hot and cold rolled carbon steel is presented.

100. Magnetic Separators

Eriez Mfg. Co. — "Non-Electric Permanent Magnetic Separators for Tramp Iron Removal" is subject of 16-page catalog No. 15. Descriptions of separators and engineering data including photos, drawings and specifications are given as well as information on selection of appropriate separators and on available engineering service.

101. Electrical Connector

Cannon Electric Co.—Illustrated data sheet RCS-1 covers CS tandem connector for electric analog computors which is also adaptable to other applications such as alternating current network analyzers. It has low resistance and capacitance qualities and single large silver-plated brass contact with ¼-in. diameter.

102. Packing and Gaskets

Raybestos-Manhattan, Inc., Packing Div.—Ninety-five types of packings and gaskets are described in 32-page illustrated catalog P-100C. Construction features, service recommendations and size information is furnished on each item.

103. Pneumatic Vibrators

SPO, Inc.—Illustrated bulletin No. 50 describes series 77 air-actuated vibrators for such applications as removing match plate patterns from sand molds, feeding small parts for assembly, settling mixes in concrete block and vault machines, and vibrating packaging tables. Vibrators deliver from 2200 to 6000 impacts per minute operating on standard 80 psi air line pressure.

104. Black Oxide Process

Mitchell-Bradford Chemical Co.—4-page illustrated bulletin MB-3 describes Black Magic type A black oxide process for steel and iron. One-bath process solution operates at boiling point of 290° F. It affords high corrosion resistance, blackens heat treated parts easily, decreases time cycle and is self-rectifying.

105. Plastic Materials

Formica Co.—Twelve 2-page catalog sheets present latest data on various Formica plastic products including rolled and molded sheet, tubing and rod. Inserts include index, military specifications, thickness tolerances and complete specifications on various grades of plastic laminates.

106. Metal Castings Impregnant

Archer-Daniels-Midland Co.—9-page technical bulletin No. 501 describes Armetol, an impregnant for magnesium alloy, aluminum bronze and other nonferrous castings. Information on equipment plus a complete impregnating procedure is included.

107. Flat-Top Conveyor Chain

Chain Belt Co.—20-page illustrated bulletin 51-60 presents details of construction and practical applications of Rex TableTop conveyor chain. Data on strength, weights, dimensions and prices are included, along with section on Rex FlexTop and Baldwin-Rex PlateTop conveyor chains and Rex Double Flex chain.

108. Coil Springs

Dudek & Bock Spring & Mfg. Co.—4-page brochure pictures wide variety of coil springs, wire forms and metal stampings. Accommodation sizes on coiling, wire forming and stamping equipment are given as well as listed manufacturing variations for coil springs.

109. Spectrometer

Titan Metal Mfg. Co.—Quantometer direct reading spectrometer, capable of giving accurate analyses of brass and bronze alloys automatically in a few minutes, is featured in 8-page booklet "Control—the Key to Improvement in Quality Products." Other control methods used in fabricating brass and bronze rods, forgings, castings, welding rods and wire are also illustrated and described.

110. Flexible Shaft Tools

S. S. White Dental Mfg. Co., Industrial Div. —50-page catalog T-51 provides listing of wide range of Flexarms and components; Flexarm accessories such as rotary files, carbide burs and abrasive points; flexible shaft combinations and accessories; resistors and molded plastics for caps and plugs. Miscellaneous products such as bench lathe, mirrors, engine belts and blowpipes are covered.

111. Cast-Weld Construction

Steel Founders' Society of America—9-page booklet presents data on technical developments in cast-weld construction field, citing examples of metals conservation, production economies, improvements in functional design and other engineering gains. Related redesign considerations as well as cast-weld principles are covered.

112. Vibration Testers

All American Tool & Mfg. Co.—6-page illustrated folder "How Much Vibration Will Your Product Stand?" gives specifications and other technical data on six models of vibration fatigue testing machinery. Testers enable pretesting of parts or assemblies to discover beforehand inherent weaknesses in design or selection of materials.

113. Aircraft Fasteners

Tinnerman Products, Inc.—Devoted exclusively to fasteners for military and civilian aircraft, illustrated "Aircraft Parts Catalog No. 500" lists all fasteners manufactured under MIL-N-3337 specifications which govern sheet spring nuts. Detailed specifications as well as possible applications are given for each Speed Nut.

114. Stroke & Revolution Counters

Production Instrument Co.—Illustrated bulletin covers stroke and revolution counters furnished with five or seven-number wheels; knob or key reset; right, left or double shaft extension and, top coming or going operation. Dimensional diagrams and prices are also given.

115. Automatic Oilers

Trico Fuse Mfg. Co.—Wide variety of visible, automatic oilers for constant level, gravity, wick, underfeed, multiple and large capacity gravity feed applications is illustrated in 4-page broadside, series 4900. Useful as a 17 x 22 in. chart when opened, folder offers suggestions for eliminating waste and hand oiling operations.

116. Air Compressors

Quincy Compressor Co.—12-page illustrated booklet "Air Makes Things Hum" shows typical applications of air compressors for controlling, spraying, starting, braking, lifting, painting, operating, lubricating, conveying, packaging, blowing and holding. Cited uses of compressors are offered as suggestions for other applications.

117. Portable Pyrometers

Wheelco Instruments Co.—Model 4 and 2385 portable pyrometers suitable for measuring temperatures of molten nonferrous alloys or maintaining consistant temperatures in liquid dyes and chemicals are described in bulletin PPY-1. Specifications on thermocouple holders and tips are tabulated, and separate price sheet provides listing of scale ranges.

118. Synchronous Motors

Ideal Electric & Mfg. Co.—"Ideal Low Speed Synchronous Motors for All Industrial Applications" is title of 8-page illustrated bulletin No. 502 which deals with 100 to 5000-hp machines in various types of constructions.

119. Stock Castings

Motors & Metals, Inc.—Illustrated stock list includes standard stock items cast in Meehanite metal. Specifications for squares and flats, rounds, bushing and tubes, flat disks, rings, angles, channels and tees are included.

120. Miniature Bearings

Landis & Gyr, Inc.—Illustrated catalog No. 7 lists data on over 250 types and sizes of miniature and instrument ball and roller bearings. Line drawings show typical applications. Engineering data are given for load calculation, shaft and housing fits, and maintenance.

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FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER

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THE AVEY DRILLING MACHINE CO.
INCORPORATED
BALL BEARING DRILLING MACHINES
CINCINNATI 1, OHIO

May 9, 1951

The Kaydon Engineering Corporation
McCracken Street
Muskegon, Michigan

Attention: Mr. J. F. Oehlhoffen
Vice President

Gentlemen:

Sometime ago we purchased some Kaydon bearings for a particular special application on one of our automatic indexing machines, and we thought you would be interested in the results.

We have completed over two million index cycles on the machine and the Kaydon bearings appear to be exactly as originally specified.

The particular application that the Kaydon bearing is being used on is a very precision, fast cycling indexing machine and since it is a new application we are particularly pleased with the results we have obtained.

Thank you again for your cooperation.

Very Sincerely,

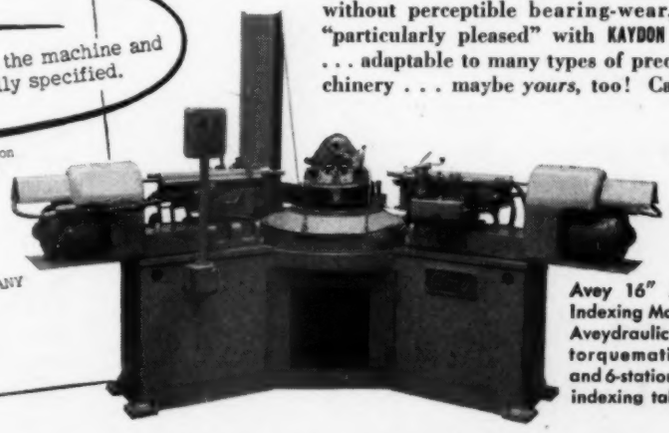
THE AVEY DRILLING MACHINE COMPANY

D. M. Patterson

DMP/wp

"no bearing wear"
in more than 2 million indexing cycles

Many are the big responsibilities successfully shouldered by **KAYDON** bearings in heavy-duty machinery. For instance, Avey fast-cycling high precision Indexing Machines demand dependable bearings to stand the strain of drilling 3 precision holes, then indexing the part 60 degrees and drilling 3 more holes. After more than 2-million indexing cycles, without perceptible bearing-wear, Avey is "particularly pleased" with **KAYDON** Bearings . . . adaptable to many types of precision machinery . . . maybe *yours*, too! Call **KAYDON.**



Avey 16" Automatic Indexing Machine, with Aveydraulic drill units, torquematic control and 6-station automatic indexing table.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

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Could you produce this part for 19¢*

This pawl is a vital part of a Bazooka

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Casting Engineers', Inc.
method is resulting in substantial economies in the production of metal parts of all kinds, especially those of intricate design or where materials used make it impossible or costly to machine.

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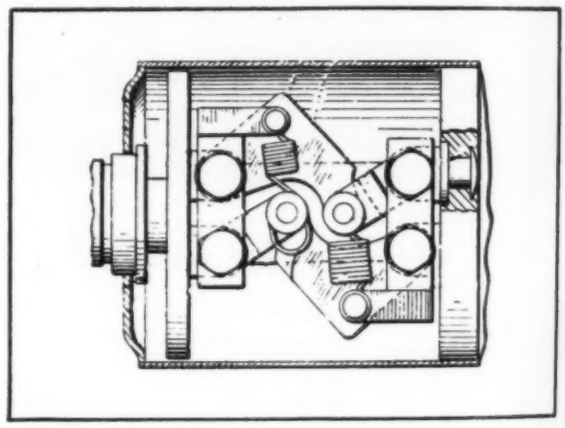
NOTEWORTHY Patents

RELATIVE ANGULAR ADJUSTMENT betwee two rotating parts joined by a speed-responsive coup ling can be varied to give an angular adjustment i one direction up to a certain rotational speed and a adjustment in the other direction above that critica speed. Either input or output shaft is splined to sleeve connecting the shafts. This sleeve is helicall splined to one and straight splined to the other shaft Axial movement of this sleeve causes a relative angu lar movement between input and output shafts. Th speed-responsive sleeve is linked to centrifugal weight that move the sleeve in one direction until the link



age is at the over-center position. If the couplin speed increases further, the linkage is thrown past th over-center position, if desired, after which the sleev is moved back toward its initial position. Helix angl weights and linkage design can be varied to give dif ferent relative positions of the shafts at variou speeds as required. The device described in this pat ent, No. 2,549,749, assigned to Bendix Aviation Cor by Walter J. Spengler, has been used to vary th spark timing in engine ignition systems.

METAL-TO-METAL CONTACT between bearin and journal, when starting hydrodynamic multipl shoe bearings from the rest position, is prevented wit the construction covered in patent 2,538,746. Tiltin bearing shoes are retained in pressure pockets cu in a bushing surrounding the spindle, pressure bein introduced into these pockets through small restrictin tubes from a pump which operates whether or no the shaft is rotating. Oil leaking from the pocket to low-pressure grooves in the sleeve between th pockets holds the shaft centered prior to starting an until a fluid film builds up under the tilting shoe as the shaft speed increases. In addition, pressure

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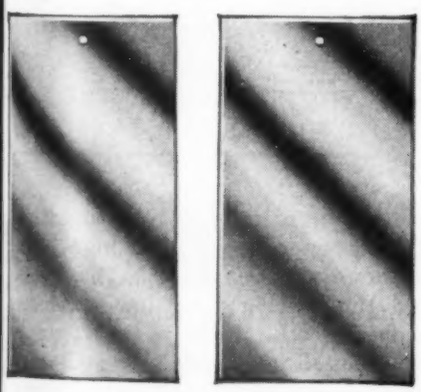
Clear Coatings for Zinc and Steel Stand 800 hours' Salt Spray

Increased use of zinc die castings and of zinc-plated steel to replace unavailable materials, combined with the tight supply of copper, nickel and chromium normally used for plating zinc, has focused attention on surface coatings comparable to plating in service performance. Unbiased laboratory tests show that at least two of the clear finishes in the company's line withstand the exceptionally long period of 800 hours' exposure to salt spray and to weatherometer tests.

Effectively protect zinc

These tests demonstrate that DULAC Clear Universal Lacquer #462 and CODUR Clear Synthetic Y743 provide completely satisfactory protection on zinc, zinc plated steel and steel. Even after the unusually severe tests to which these finishes were subjected, there was no indication whatever either of failure of the coating or of discoloration of the zinc.

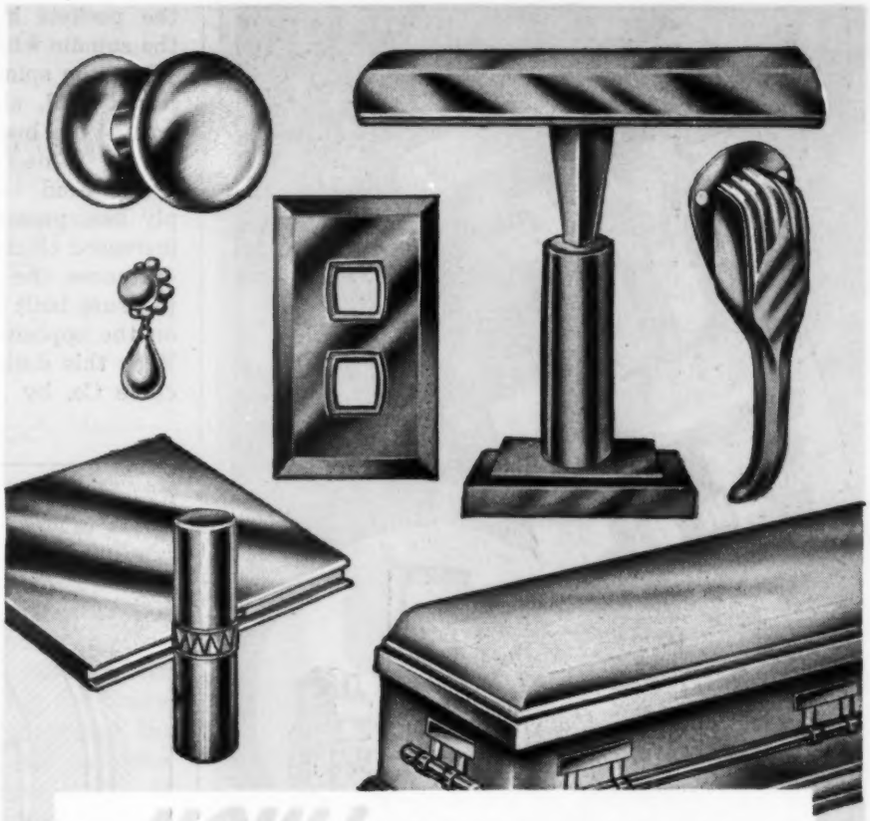


(Left) A zinc-plated steel panel newly coated with DULAC #462. (Right) A similar panel after 800 hours' exposure to salt spray, showing no evidence of attack on the finish.

Adaptability to Drying Schedules

While both finishes give the same performance, DULAC #462 is an air-drying coating, while CODUR Y743 is a baking type. This permits choice of the correct finish to fit into the drying schedules of a particular finishing room.

Technical Data Bulletin #110 on clear finishes is available from Maas & Waldstein Co., 430 Riverside Avenue, Newark 4, N. J. On request, M & W Technical Service Engineers will discuss specific problems.



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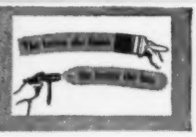

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Write for Bulletin 4458. WARD LEONARD ELECTRIC CO., 58 South Street, Mount Vernon, N.Y. Offices in principal cities of U. S. and Canada.

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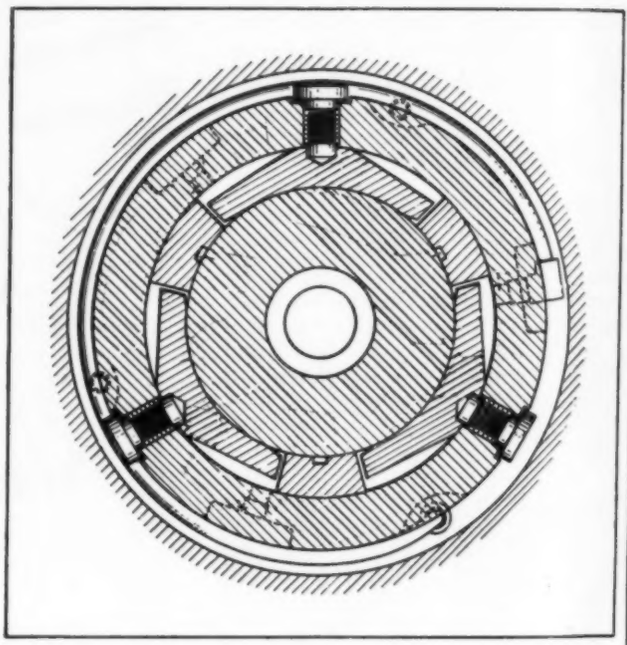
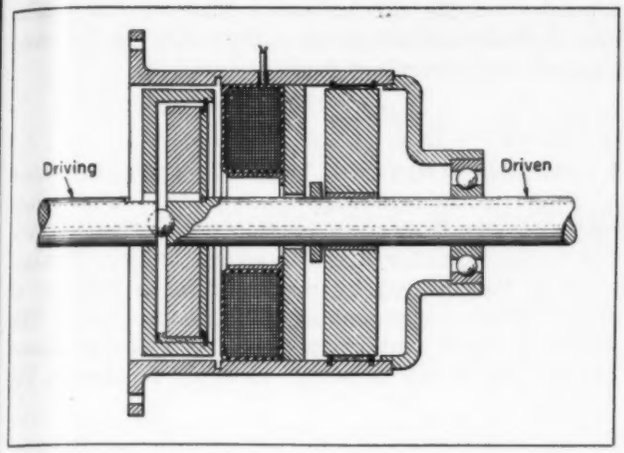
the pockets helps to resist radial displacement of the spindle when shock loads are applied to the shaft. When the spindle starts to deflect because of an external load, clearance between the spindle and the part of the bushing toward which the spindle is being moved is decreased, the volume of the pocket decreases and, because of the restriction in the oil supply line, pressure in the pocket increases. Similarly, increased clearance on the opposite side of the spindle decreases the pressure in that pocket. The higher pressure built up on one side and the lower pressure on the opposite side both tend to recenter the shaft. With this design, assigned to Cincinnati Milling Machine Co. by Albert H. Dall, one bearing clearance



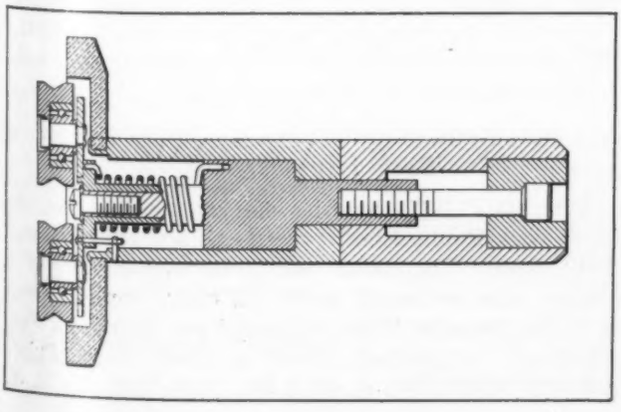
adjustment suffices for both low and high-speed operation. Sufficient clearance can be set for high-speed operation (where the hydrodynamic film has been built up all around the bearing), yet low-speed operation is possible because the pressure pockets provide impact load protection at speeds where the hydrodynamic film has been established only on the dead-load side of the bearing.

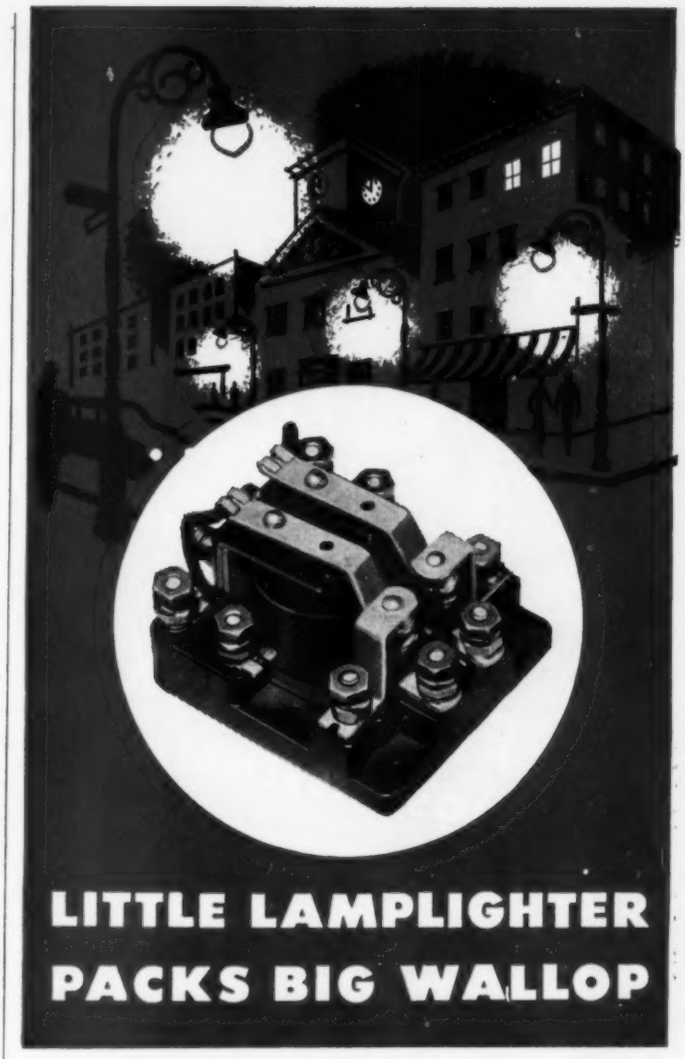
MAGNETIC CLUTCH-BRAKE MECHANISM covered in patent 2,544,360, assigned to General Electric Co. by Marvin L. Schmidt, uses magnetic fluid to provide a brake requiring no moving parts or actuating springs and eliminating wear at the braking surface. The air gap between a permanent magnet mounted on the output or driven shaft and the stationary housing is filled with a magnetic fluid such as powdered iron particles suspended in oil. With no current flowing to the clutch exciting coil, flux produced by the permanent magnet travels the air gap between magnet and housing, through the housing, through a stationary wall or disk between the coil and the permanent magnet, and along part of the driven shaft, solidifying the magnetic fluid and braking the output shaft. Ex-



citing the clutch coil sets up another flux path through the housing, a cup-shaped flange on the input shaft, a disk on the end of the output shaft, and the stationary barrier wall. The clutch coil can be designed to set up a flux flow in the barrier wall that cancels the effect of the permanent magnet flux. Therefore, energizing the coil releases the magnetic fluid between permanent magnet and housing, removing the brake. At the same time, the coil flux traveling through the air gap between input cup and output disk solidifies that magnetic fluid and drives the output shaft. If the exciting coil is connected in the energizing circuit of the electric drive motor the device will control overspeeding caused by light or overhauling loads. Overspeeding of the driven shaft is prevented since exciting current to the clutch coil drops as motor load decreases and a braking torque is imposed on the output shaft until the motor energizing current returns to normal.

TENSION MEASUREMENT in a moving strand of yarn can be accomplished with a coil-spring actuated portable tensiometer described in patent 2,538,932. The yarn strand is looped around two grooved wheels mounted on a carrier plate. This plate is fastened to one end of the spring, with the other end of the spring secured to the handle. Tension in the strand rotates the carrier plate in relation to the handle, against the resistance of the spring—the amount of tension being indicated by relative rotation between





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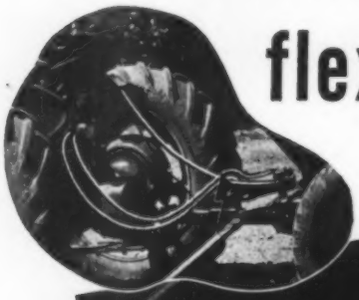

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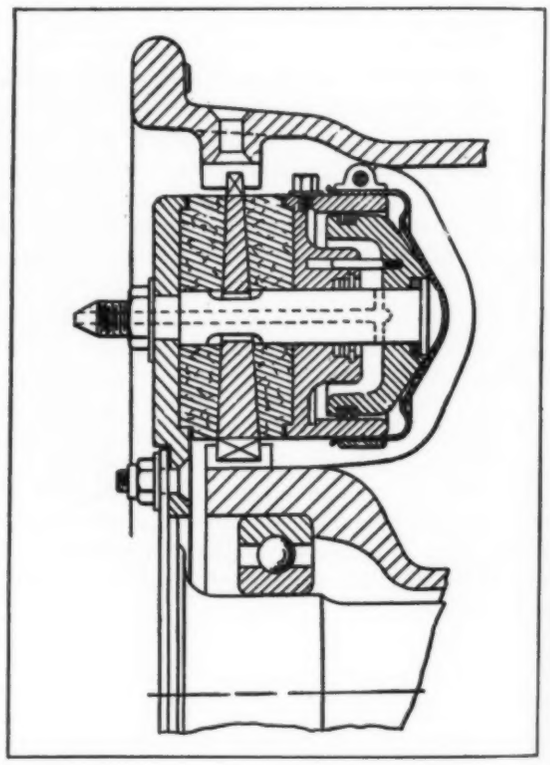
a pointer on the carrier and a scale on the handle. Paul J. Campbell has assigned the patent to Raymond Engineering Laboratory Inc.

COMPENSATION FOR WEAR in friction surfaces of fluid pressure operated disk brakes is obtained automatically through a friction connection between the brake actuator and its return spring. Braking force is transmitted by movement of a cylinder or sleeve member surrounding a hydraulic piston. This piston is held stationary and the cylinder moves (to the left in the drawing) to apply the brake. The



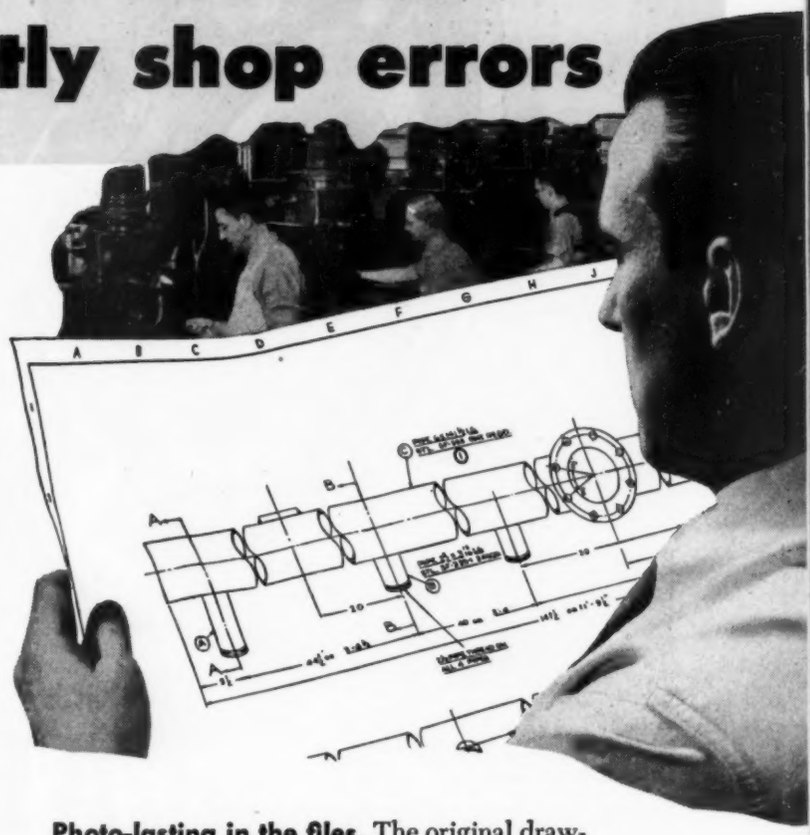
return spring, a flexible cup, dome-shaped on one end and held to the sleeve only by friction of a clamping band, slips axially relative to the sleeve until slack between the friction and sleeve members is taken up. When wear of the friction surfaces occurs, the sleeve moves a greater distance, axially, to apply the braking force, slippage occurring between spring and sleeve. When brake pressure is released, the return spring disengages the friction surfaces and pulls the sleeve back a distance equal to the spring extension to give the desired constant clearance. The patent, No. 2,541,-032, has been assigned to Dunlop Rubber Co., Ltd., London, England, by Henry J. Butler.

Back Issue Wanted!

TO COMPLETE its files of MACHINE DESIGN, the New York Public Library needs a copy of the March 1949 issue. The favor would be appreciated if a reader, who no longer needs his copy, would present it to the library. Please communicate with J. R. Fall, Chief of Acquisition Division, New York Public Library, Fifth Ave. & 42nd St., New York 18, N. Y.

Cooper-Bessemer Corp. Calls Kodagraph Autopositive Paper

Low-Cost Insurance against costly shop errors



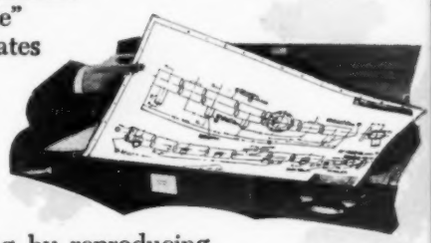
• Cooper-Bessemer, leading manufacturer of engines and compressors located in Mt. Vernon, Ohio, must supply its branch factory with intermediates (print-making masters) of home-office drawings.

But they realize that poor intermediates—like poor tracings—often produce illegible shop prints ... which, in turn, can lead to costly errors on the production line.

It doesn't pay to take chances when thousands of dollars are at stake. Therefore, Cooper-Bessemer makes intermediates on Kodagraph Autopositive Paper, which reproduces original detail as dense photographic black lines on a clean, evenly translucent paper base.

These intermediates assure highly legible shop prints at Cooper-Bessemer's branch plant in Grove City, Pa. Even after hundreds of machine feed-throughs, Autopositives produce sharp, clean prints which are easy to read. And there's another advantage—print production is simplified, for Autopositives can be run at uniform, practical machine speeds—without frequent adjustments.

Photo-lasting in the files. The original drawings are 200 miles away, but Cooper-Bessemer's Grove City plant has full confidence in its 100% "Autopositive File" —no worries about intermediates fading, becoming brittle, or otherwise deteriorating. *Another important "extra."*



Extending Use of Autopositive. The assembly lines at Cooper-Bessemer's home plant are also seeing shop prints produced from Autopositives—will soon see many more. Plans are under way to protect some 50,000 valuable originals against the wear and tear of print-making by reproducing them on low-cost "Autopositive." The same production routine currently employed will be followed: *exposure* in a direct-process machine; *development* in standard photographic solutions.

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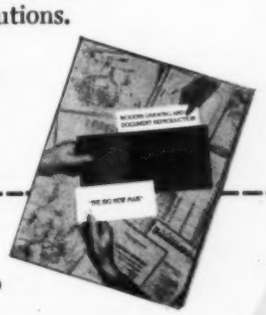

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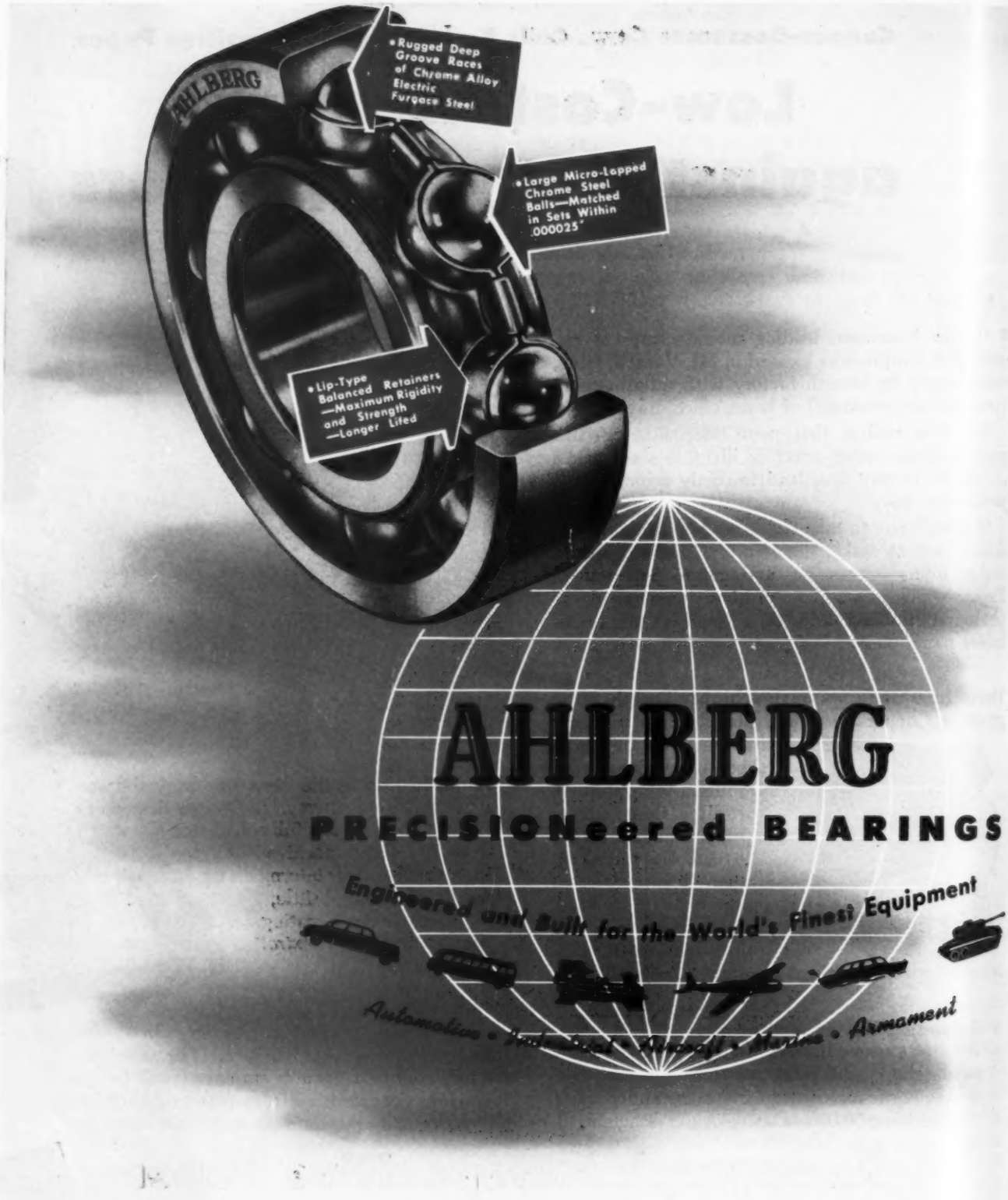
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Applying Torque Converters to Crane Drives

(*Continued from Page* 116)

mand. The benefits in reducing maintenance, saving fuel, and eliminating wear and tear on the operator from reduction of noise and vibration are well received gains.

A small quadrant is located at the engine with a locking arrangement so that the governor setting may be moved from any position from about 200 to 1000 rpm, and will remain in that position.

A schematic arrangement of the tail-shaft governor is illustrated in *Fig.* 25, showing a conventional flyball mechanical governor rather than the fluid governor actually used. The governor is geared to the converter tail shaft, as indicated. The governor riser is loaded in the usual way by a spring, the compression of which may be varied to change the speed at which the riser will move. This loading spring is connected to the governor speed-control quadrant (not shown in the illustration) so that the pressure on the spring is varied by moving the lever in the governor speed-control quadrant, thus changing the actuating speed of the governor.

Governor Maintains Output Speed

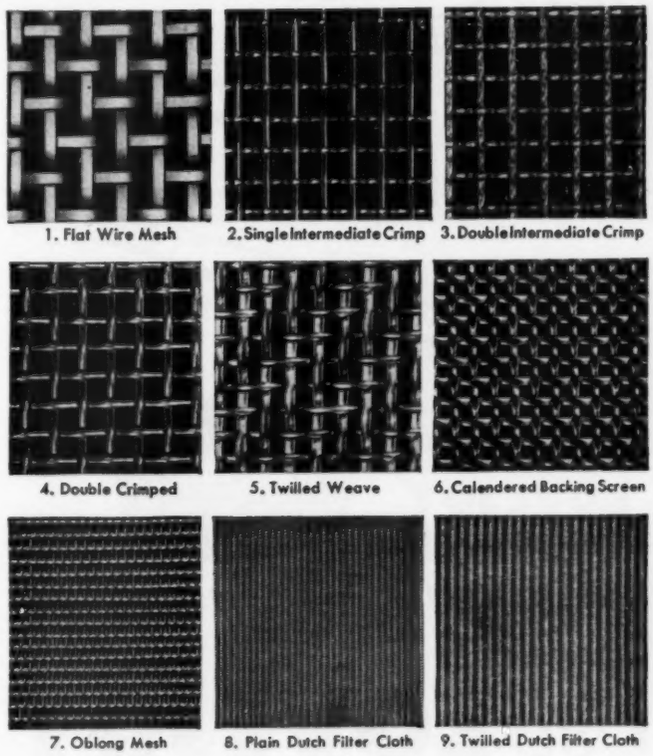
In the usual governor arrangement the riser would be connected by suitable linkage direct to the fuel valve. To secure throttle control, however, connection is to the differential lever as indicated in the drawing. One end of this lever connects to the fuel valve and the other, through suitable linkage, to the throttle control located at the operator's position. Moving the throttle changes the fulcrum point of the differential lever but still leaves the governor acting on the fuel valve at substantially the same speed.

With the throttle control lever in midquadrant, as shown, there is no effect on the operation of the fuel valve by the governor. If, however, the throttle lever is moved to the right, moving the differential lever fulcrum point to the right, a limit is placed on the amount of fuel injection into the engine. With the throttle lever in full-right position, throttle is held in idle setting regardless of governor demand.

Moving the lever in the reverse direction has the opposite effect. The fuel valve is positively held open a minimum amount and, with the lever in full-left position, the fuel valve is held wide open regardless of governor demand. This furnishes output-shaft speeds above governor setting. It should be mentioned in this connection that the engine is also provided with a limiting speed governor, mounted on the engine and actuated by it, to prevent excessive engine speeds, regardless of throttle setting.

With this arrangement the operator can, by pulling the throttle lever to the right idle position, hold the fuel valve closed (idle). If he then engages his travel clutch, the tail shaft will be brought to a standstill with substantially no torque applied to the wheels. Then, as the throttle lever is moved toward

9 REASONS for specifying Cambridge Industrial Wire Cloth



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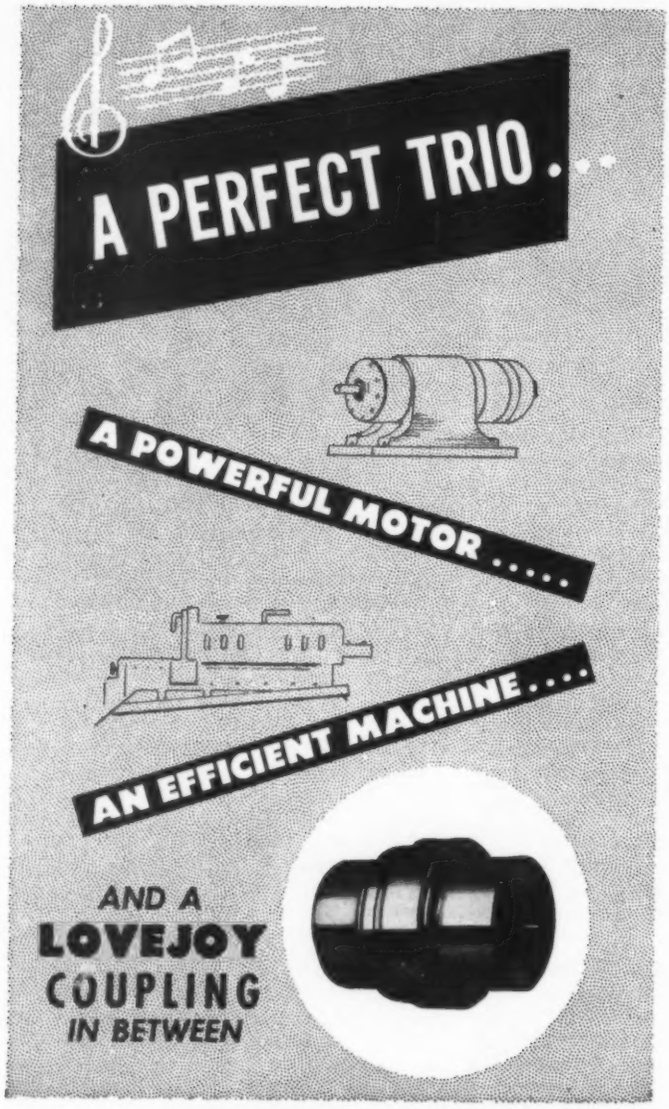

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the midposition, the fuel valve will be opened proportionately to the throttle setting until the tail-shaft speed rises to the governor set position.

In *Fig.* 26 is a plot of the travel characteristics of a 25-ton crane. Net draw-bar pull available at the crane coupler is plotted against crane speed.

A similar plot, *Fig.* 27, gives hook load against hook speed for the usual arrangement of a 4-part fall block and for various throttle openings. With full governor control, that is, hand throttle in mid-quadrant (*Fig.* 25), the hook is held to the nominal fifty feet per minute, regardless of hook load, varying only due to governor regulation. As before, the engine speed varies as the tail-shaft governor varies the throttle opening to meet the load placed on the hook. Full throttle gives a load capacity well beyond rated, so that ample reserve is available.

Throttle Sets Controlled Speed

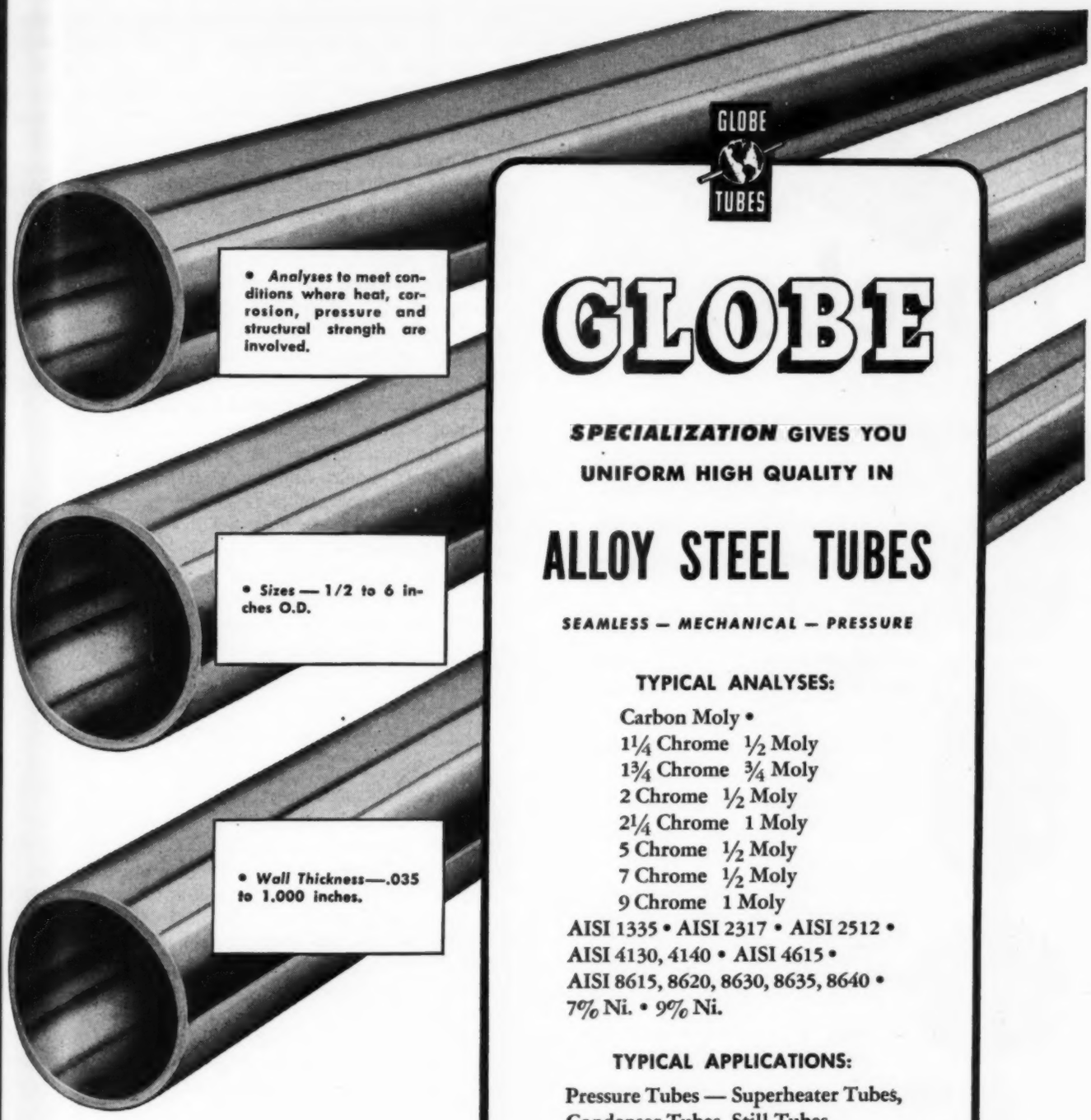
If it is desired to hold a maintained speed greater or less than that shown, the lever in the governor speed control quadrant is reset to whatever controlled speed is desired. A position of 25 fpm (nominal) is shown on the chart.

Throttle control of the hook may be obtained by simply moving the throttle lever, *Fig.* 25, part way to the idle position, limiting throttle opening and controlling speed, as indicated. As an example of this action: with a 25-ton load on the hook and with one-fourth throttle, hoist would be at 5 fpm. If the throttle were closed slightly the load would slow up until, at about 0.2 opening, the load would balance in air. If the throttle were closed still further the load would descend slowly. Opening throttle above one-fourth will raise hook speed until, at about 0.7 throttle, the governor takes over. If higher speed should be desired it is simply necessary to move the throttle past the midpoint until the hand control takes over *minimum* opening, whereupon line speeds above governor setting are obtained. This action exists without disturbing the governor setting.

It is extremely unusual for a crane—in fact, as far as that goes, for any piece of machinery—to operate under full load for long periods of time. Usually, if full load is constantly demanded the engine installation is too small for the job it has to do. Now, as before mentioned, efficiency of a fluid converter is markedly improved under part-throttle; particularly if the engine operates near coupling range.

On this application, owing to the tail-shaft governor control, the engine is able to operate much of the time near coupling range, and most of the time at a much lower speed than it would in a conventional arrangement. This, in itself, gives a saving in engine friction losses. The result is that experience so far has indicated that the overall fuel economy on the average converter installation is just about on a par with that of a mechanical installation.

It is apparent that the converter heat, besides being a function of the converter, is also a function of the job the converter is asked to do, so that it cannot be categorically stated that this or that unit is satisfactory. Without question, the worst heat disposal problem occurs under full load with stalled tail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shaft. This condition can be expected in car switching operations, floating heavy loads, etc., and should be expected as an operating abuse that may occur from time to time. The converter should be able to meet stall conditions for a certain period of time and even if this time is exceeded it should not result in permanent damage.

In an attempt to reproduce extreme field conditions the crane was operated on heavy switching operations until temperature balance in the converter fluid had been reached at about 170 degrees. Travel was then fully blocked and throttle opened wide for a full five minute period during which time the oil temperature rose to 240 degrees. As this was felt to exceed the longest expected stall, blocking was then removed and the machine put back to work switching. At the end of twenty minutes the oil temperature had returned to 180 degrees, just 10 degrees above the heat balance point reached originally.

But what would happen if stall had been maintained? Experiments have shown that the oil temperature may rise as high as 300 degrees, at which point vaporization begins and torque output is suddenly lost. Since this would be definitely objectionable, the converter is arranged with a suitable alarm to indicate when 250 degrees is reached, giving a wide margin of safety, as heat disposal obviously increases with temperature rise.

Acceptance Is Vital to Design

Customer acceptance of a new design is often overlooked by the technical man. There is no point to the entire development unless the resulting product can be sold at a profit. No matter how good the idea, if the prospective purchaser does not agree with you and is not willing to back up his judgment and yours with his dollars, the design is not acceptable.

Locomotive cranes are bought by men whose work is such as to make them conservative. What will be their sales attitude? A sampling of the trade indicated that every one, with hardly an exception, would be interested and would follow developments carefully, but that few would purchase the unit until considerable application in the field had proved its worth. It was felt, however, that if the initial application were carried through, the unit would prove itself and become salable. Financing considerations, then, must allow for this carry-over. Since a locomotive crane is, obviously, an expensive piece of equipment, this was a major consideration.

A number of converter cranes have been placed in the field since the first installation. In all cases they have more than met expectations. Many converter applications have been made to other machines in the heavy equipment field. There seems little question that it is only a matter of time until the converter becomes the universally accepted diesel drive for variable output loads. However, it must not be assumed that all that is needed is a converter or that any one type is the universal answer. Each application must be thoroughly studied, all alternatives weighed and selection made with analytical care or disappointment will be the product.

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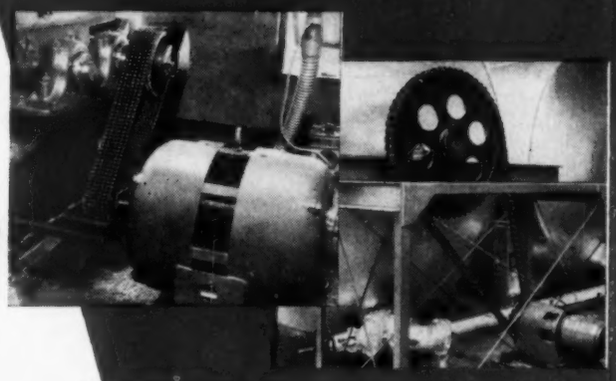

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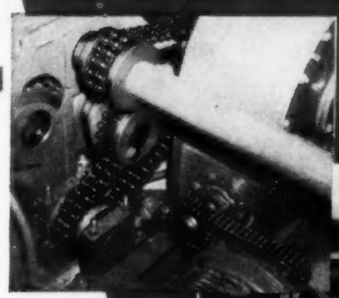

- **MACHINERY APPLICATIONS**
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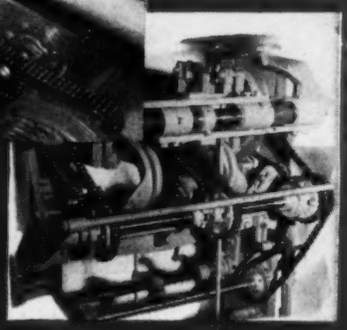
  Multiple Shaft Drives
  Transmissions



- **CONVEYOR DRIVES**
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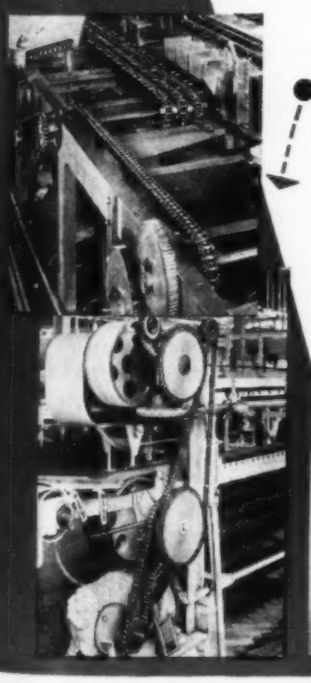
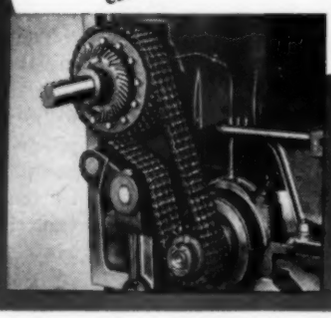
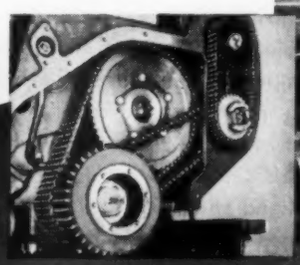
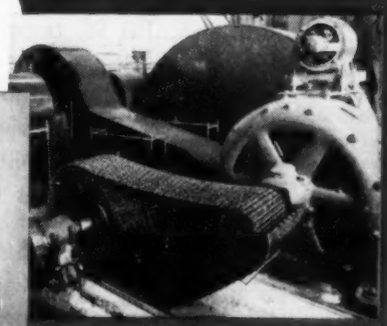


- **ENGINE APPLICATIONS**
  Timing • Pump Drives • Power Take-off • Generator Drives • Supercharger Drives • Accessory Drives







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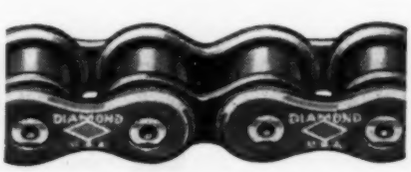

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The DC reversible motor turns at speeds of ⅓ r.p.m. to 6 r.p.m., dependent on torque requirements. The swing of arm attached to the shaft is controlled by limit switches. Thermo Bulb A, filled with liquid, is immersed in the coolant or oil. As the temperature increases, the liquid in the bulb expands, forcing movement of a plunger in Bellows B against a contact at C. The same movement of the plunger swings the pivoted Chace Thermostatic Bimetal element D against the left hand spring contact at E which determines direction of rotation of the motor. The prime function of the thermostatic bimetal, however, is to compensate for gain or loss of heat in the capillary and bellows caused by changing ambient temperatures. As the bimetal reacts to the changing temperatures, it makes the shutter action early or late, to suit conditions.

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Thermostatic Bimetal
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Design Abstracts

(*Continued from Page* 162)

first and the air gap last. Obviously, if the insert is loose, or incorrect on the wider limit dimensions, there is no reason to gage further. Wear on the close-tolerance air-gap gages is thereby reduced.

The fourth indexing carries the part to a reject station, where it is ejected if proved incorrect at previous gaging. The fifth is a gaging station, the sixth a reject, and so successively, with accepted parts dropping through the good parts exit to the conveyer.

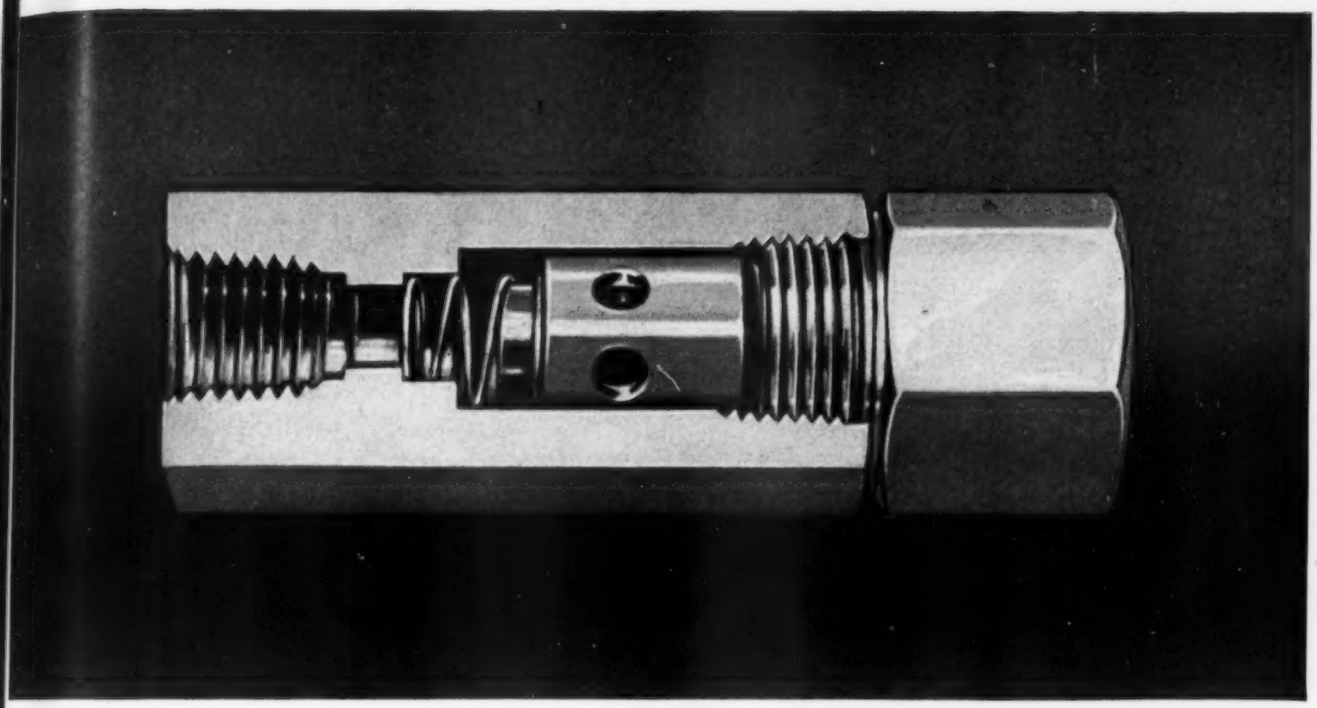
Also shown are three of the 16 memory pins, the switch which is actuated by the memory pin at the next, or reject station, and the cam which restores the memory pin to its normal position. The switch, the cam, and the two associated solenoids are in fixed positions, while the memory pins are indexed with the carrier table.

In any automatic machine, proper timing of the various interlocking functions of the mechanism is of vital importance. Incorrect design or construction can lead to disastrous results. In our gaging and sorting machine, the operating cycle is 1 sec of time, during which all the various functions are performed. The various controlling cams make one revolution per second and the time chart, *Fig.* 5, shows just what happens during the 360 deg of rotation.

The indexing of the carrier, moving the protector blocks from one station to the next, occupies 165 deg or 0.458-sec, somewhat less than half the whole time. When the indexing is completed, the gaging heads are permitted to descend and the gages contact the part and assist in holding the plate stationary. This takes 45 deg or ⅛-sec.

There is then a lag of 50 deg, less than 1/7-sec, and in this period all the gaging heads come to rest, with the open or closed condition of the various contacts established by the dimensions of the parts. During 45 of these 50 deg, air is blown on the part in the cleaning station. After this lag of 50 deg, the gage-energizing cam then permits current to flow for 70 deg or 0.195-sec.

Twenty-five degrees or about 0.07-sec after the gaging current is applied, the reject circuit is energized. This is held on for 40 deg or 1/9, sufficient time to operate the relays and solenoids which, through the memory pins, open the trap doors for rejects. Finally the lifting cam, in 25 deg, or again 0.07-sec, raises all



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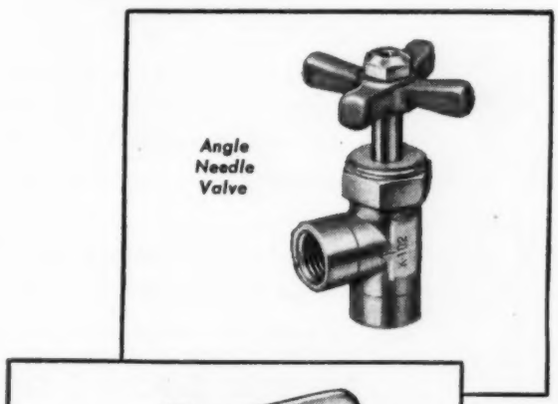
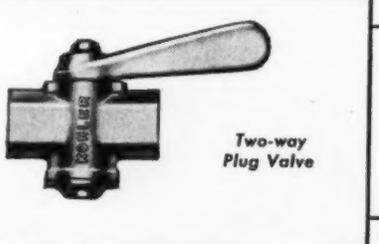
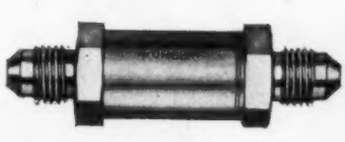


Angle Needle Valve



Two-way Plug Valve



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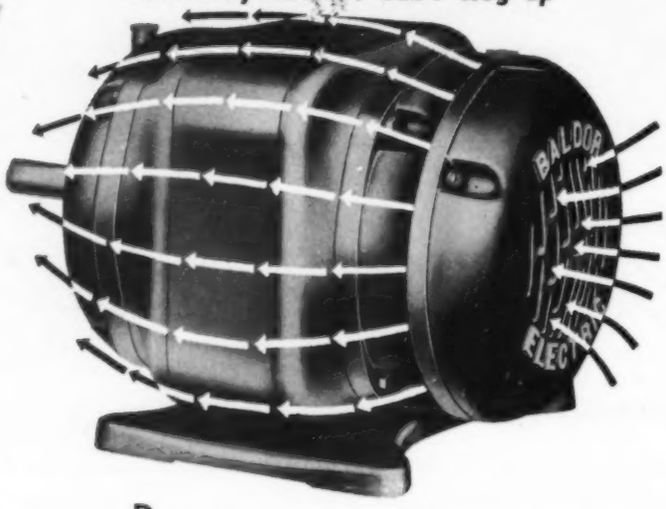

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the gaging heads in time to permit the indexing to start again.

The precise timing necessary for the proper functioning of the machine is not quite the simple matter of energizing the solenoids which have been shown in schematic form. Many relays were required to set up circuits and to provide short periods of time delay. These relays and other electrical devices are mounted on an electrical panel.

Details for the first gaging station, at which the carbon insert is checked for looseness or improper cementing in the porcelain block, are clarified in *Fig.* 6.

The lifting spider holds the gage slide up, and through a lever the retracting rod holds the lower gage block down so that the part may be indexed, without interference, to position for gaging on top of the carbide insert, or for rejection, over a trap door. As the spider descends, the gage slide moves toward the part being gaged under the tension of the return spring.

Dimension and Strength Checked

Movement of the lever and the retracting rod allows the carbide gaging tip to come into contact with the lower or sparking surface of the insert. The contacts in the microswitch are opened. As the slide descends further, the 15-lb load is applied to the top surface of the insert. Should the insert be loose or the air gap less than the minimum, the microswitch contacts will be closed. This will actuate the memory pin solenoid, and at the next reject station the defective part will drop through the trap door and down the segregating chute.

The maximum 0.220-in. minimum 0.205-in. dimension is checked at the third gaging station. This gage, *Fig.* 7, is similar to No. 1 gage, *Fig.* 6, except that a bidirectional switch replaces the single limit microswitch.

As the head descends the gaging tip is brought against the spring surface of the carbon insert. Fastened to the fixed block are reeds which hold the movable block. Also attached to each block is one of another pair of reed springs which support and actuate the contact-operating arm. This arrangement not only gives a high magnification but is positive in its action. Should the part be over the maximum dimension, the gaging tip will, through the movable block, lift the left-hand reed spring, causing the upper end of the arm to swing to the right. The insulated tip will pass through a slot in the fixed and adjusted contact spring and, by pressing against the other contact spring, will break the circuit to a relay. The

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relay in turn will then close the circuit to energize the reject solenoid which actuates the memory pin. Should the part be under the minimum, the left-hand pair of contacts functions in similar manner.

Sorting at No. 3 gage is more complicated than at No. 1 and 2, and is done by a gate below the trap door, *Fig.* 8. The contacts shown in upper left-corner represent those of the relays which are actuated by the contacts in the limit switch shown in *Fig.* 7. These relay contacts, in addition to operating the memory-pin solenoid, also energize the rejection-gate solenoids, which in turn position the sorting deflector.

From a paper entitled "Design of a Semiautomatic Gaging-and-Sorting Machine," presented at the ASME Semi-Annual Meeting in Toronto, Ont., June 11-15, 1951. *Complete copies may be obtained from ASME, 29 W. 39th St., New York* 18; $0.25 *each to members,* $0.50 *to nonmembers.*

Engineering Investigation via Statistical Techniques

By Carl V. Garrett

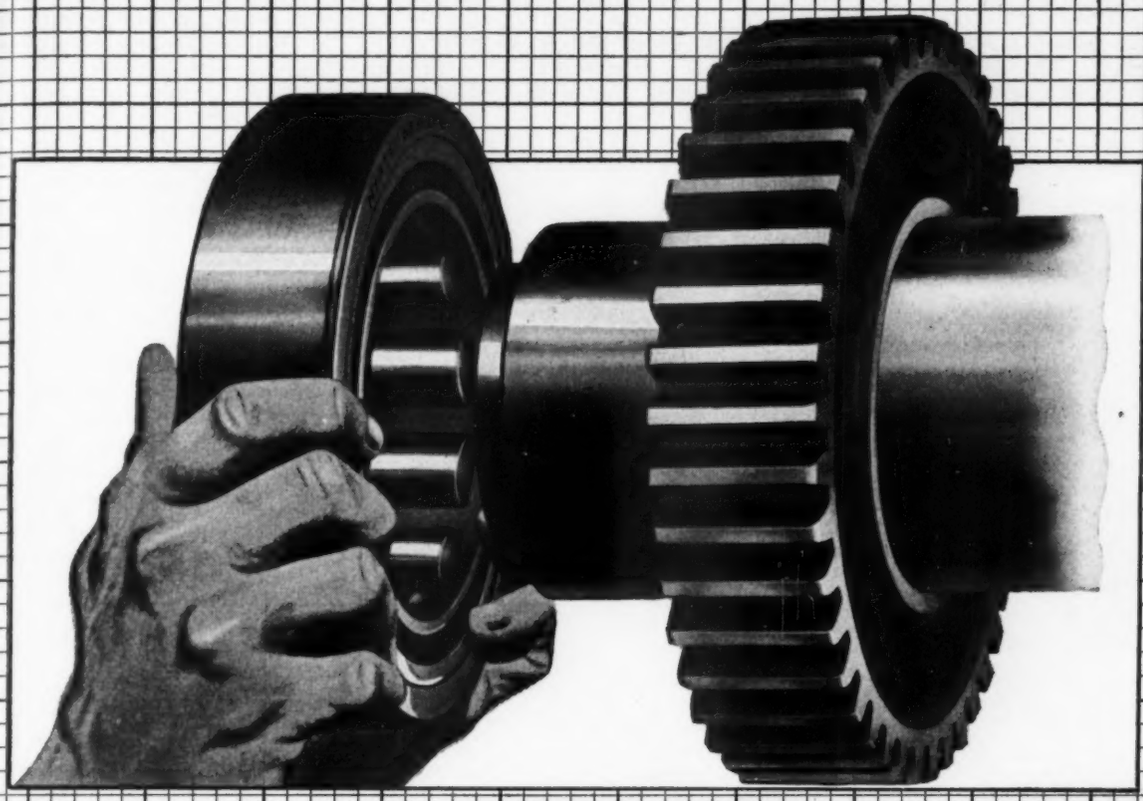
Allison Div., General Motors Corp. Indianapolis, Ind.

EARLY in 1948, our engineering department finished the design of an improved torque converter model and turned the prints over to our model shop to build two or three units for test purposes. The units were built, tested, and after several teardowns and reassemblies to incorporate numerous changes were ready for final testing.

Most engineering test specifications are established from results obtained during the final testing. Usually a very limited number of observations is obtainable at this time.

On this particular torque converter model, an engineering specification of X per cent ± 1.2 per cent has been established as the desired efficiency. The unit was then released for production and almost immediately difficulties were encountered in an attempt to obtain this efficiency. As is the usual case, this failure to meet the specification resulted in considerable teardown, rework and reassembly, which quite often failed to accomplish any improvement.

Statistical techniques were used to investigate the major characteristics



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DENISON PUMPS

which should have contributed to poor efficiencies. These studies indicated we were maintaining reasonably good control of these several major variables. Obviously, it was impractical to investigate or chart all the variables that might affect the efficiency.

After we had been in production several months and had failed to make any significant improvement with regard to the efficiency, it was decided we should build a histogram and calculate a frequency distribution curve from the values recorded from the last hundred or more torque converters produced. The histogram and calculated frequency distribution curve indicated we were producing units that formed an extremely normal distribution of efficiencies.

We compared these factual data with the engineering specification and found the mean of the actual distribution to be 1.4 per cent below the mean of the specification. The six sigma spread was also found to be 3 per cent. About 34 per cent of the units produced were meeting the established efficiency specification with the balance of 66 per cent falling under the low limit to an extreme of 1.7 per cent.

How To Solve the Problem

We now realized that we had a manufacturing process that was just not capable of producing all units to meet the established specification. This presented us with a problem. Would we make major changes in the process? Would we revise the specification to agree with the process? Or, would we establish some salvage limit that would allow us to accept most of the units while we were making additional studies to determine which changes in process and engineering would be best in order to effect increased efficiency? We chose the latter course and established a salvage limit that permitted acceptance of virtually 100 per cent of the units being produced while further investigations were made. We felt justified in following this course of action even though we were not meeting our desired efficiency, because the units we were producing surpassed the efficiency of comparable competitive units.

During the next few weeks, numerous intensive studies were made and we soon realized that any significant change in the efficiency level would necessitate some very expensive processing changes in addition to some engineering changes. After much discussion we decided against making these changes for two reasons. One, the increased efficiency that could be obtained did not warrant the expenditure that would have been necessary

The other, we anticipated discontinuance of this model in favor of an improved design that would be released to production. Eventually this improved model was released and subsequent testing of several production units proved it to be quite satisfactory.

Probably one more comment should be made regarding our torque converters. When new torque converter models are designed and developed it is still the policy to establish engineering test specifications on the drafting board and from results obtained from observations made during final testing of model units. However, specifications are now based upon a greater number of observations than was the practice in the past. In addition there have been several occasions where factual data gathered during the testing of production units have prompted revisions in the specification, provided the test values obtained were satisfactory.

From a paper entitled, "The Use of Statistical Techniques for Investigational Purposes," presented at the Fifth National Convention of the American Society for Quality Control in Cleveland, May 23-24, 1951.

Fluid Film Capacity

By Ernest K. Gatcombe
U. S. Naval Postgraduate School
Annapolis, Md.

THE main problem is the investigation of the thickness and the corresponding load-supporting capacity of fluid wedge-shaped films entrapped between the peripheral surfaces of circular rotating disks on parallel shafts, which have their center-to-center distance constantly changing, so as to cause the film to become alternately thin, then thick at moderately high frequencies.

An exact analytical solution to the steady-state problem is secured. The nonsteady-state problem was solved by experimental means; it is much too complicated to solve by analytical methods if one retains such factors as the deformation of the surfaces of the disks, surface roughness, etc.

A prominent characteristic of the load-supporting capacity of fluid films has been uncovered in this research. It is definitely shown that thin fluid films strongly resist being squeezed out from between metal surfaces, especially if the bounding surfaces are approaching each other at high velocities. In other words, the

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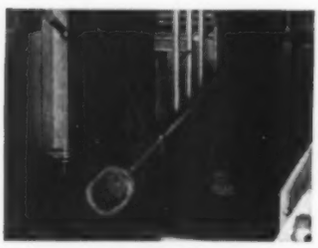

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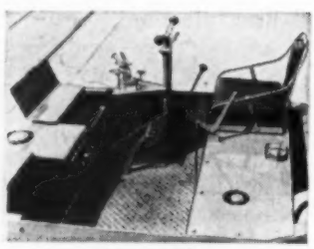

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nonsteady-state character of the motion of the bounding surfaces of fluid films is responsible for their ability to support relatively great loads.

The steady-state theory never has been able to account satisfactorily for the relatively large loads which bearings and gears carry every day. This theory indicates unreasonably thin film thicknesses for these members when used with heavy loads at low speeds; many times these thicknesses are much smaller than the surface roughness of the metal bounding surfaces. Neither can the theory account for the loads which are carried successfully in high-speed gearing such as in certain turbine gear units. In such cases the period of mating is very short, and the whole lubrication phenomenon is nonsteady state, without question. It is highly probable that the prominent point uncovered in this work partly explains why such gears actually work.

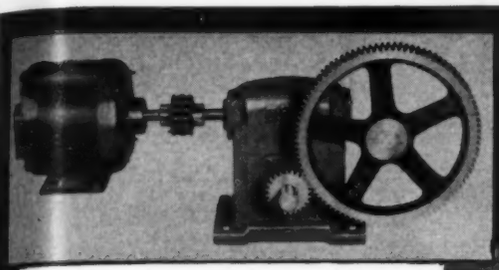
Data Widely Applicable

Two external-type cylindrical disks, which formed the metal bounding surfaces of the fluid film under investigation, were chosen in this work in preference to actual bearings, because of their basic character in relation to gears as well as to bearings. The results of this work may be used in studies of gears as well as in internal and external bearings. For one of the cases examined in this work, the nonsteady-state figures collected from actual experimental tests indicated that the film under investigation carried a load *six* times as large as the steady-state solution would have indicated.

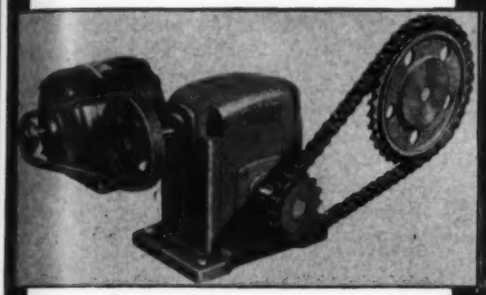
It has been the opinion of this author for some time that theory alone is an insufficient tool for completely explaining some of these complex lubrication phenomena. Thus, at the Naval Postgraduate School, the last three years have been spent in acquiring and testing accurate instruments for carrying out this mission. It cannot be overemphasized that actual operating conditions have been simulated and that actual steel disks with real lubricants were used. These disks are deformable: they have surface roughness; they have certain adhesive and cohesive properties. The lubricants act in their natural fashion. Above all we have worked with nonsteady-state conditions.

From Paper No. 51—*SA-5, "The Nonsteady-State Load-Supporting Capacity of Fluid Wedge-Shaped Films," presented at the ASME Semi-Annual Meeting in Toronto, Ont., June* 11-15, 1951. *Complete copies may be obtained from ASME,* 29 *W.* 39*th St., New York* 18; $0.25 *each to members,* $0.50 *to nonmembers.*

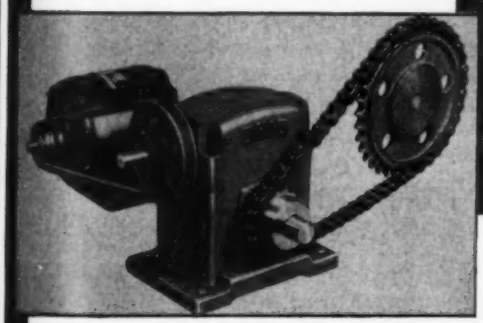
STANDARDIZE WITH OHIO



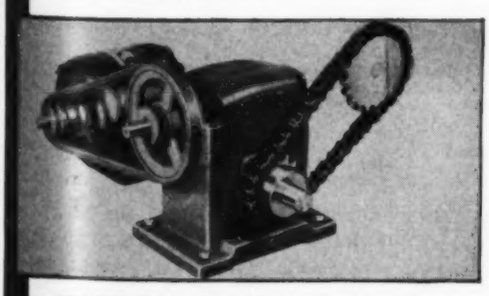
GOOD PRACTICE: reducer driven direct through flexible coupling, no overhung nor bending load. Additional reduction through spur gear mounted on output shaft close to housing.



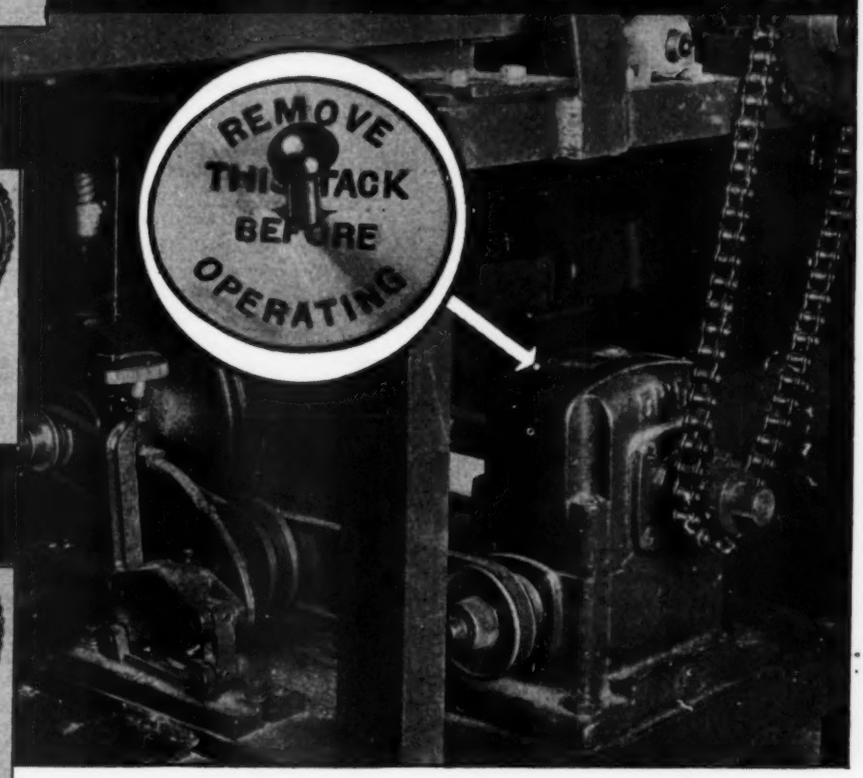
BAD PRACTICE: additional reductions in good balance but drives mounted too far from housing, leading to excessive bending load.



GOOD PRACTICE: where additional reductions are required; V-belt drive from motor to reducer, chain drive from reducer output shaft. Ratios balanced, with larger ratio from output shaft. Drives mounted close to housing to eliminate excessive bending load.



BAD PRACTICE: additional reduction drives correctly mounted but out of balance. Large reduction between motor and reducer, subjecting reducer to possible overload.



Today, the proper installation and maintenance of Ohio Stock Speed Reducers is good insurance against breakdown and faulty performance at a time when replacements are hard to obtain. Close attention to the following points will prolong the life and increase the efficiency of the entire drive.

Mount on solid base to prevent vibration. Vibration results in excessive bearing and gear wear leading to noisy operation. Check the shafts of each unit for proper alignment. Use flexible couplings to compensate for any shaft misalignment and shaft end-plays.

Should reduction in addition to that of the speed reducer be required it is advisable to confine it to the slow speed shaft. This diminishes the load on the reducer in direct proportion to the ratio and acts as a safeguard in absorbing shock. If it is necessary to interpose a reduction between the primary power and the reducer, the ratio should be kept as small as possible. In either case the sprockets, pulleys, cranks or gears should be mounted as close to the bearings as proper clearance for drive will allow, in order to keep bending load at a minimum. In case of excessive bending or overhung load, it is advisable to install an outboard bearing. When installing driving member on reducer shaft, prevent use of force which might bend shaft and damage bearings.

Failure to remove tack from vent hole, as illustrated above, will result in pressure being built up in unit causing excessive heat and premature oil leakage.

OHIO GEARS

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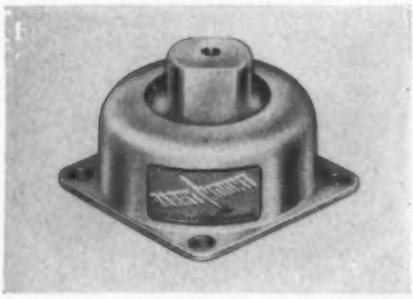
SHOCK and VIBRATION NEWS

BARRYMOUNTS FOR ASSURED CONTROL OF SHOCK AND VIBRATION

NEW ALL-METL BARRYMOUNTS

for Unusual Airborne Applications



These new Barrymounts provide the aircraft and electronic engineer with a vibration isolator designed to meet the unusual temperature and environmental conditions encountered in high-altitude, high-speed flight. Employing no organic materials, these mountings are not subject to temperature influences that may affect the performance of other mountings.

ALL-METL Barrymounts offer a wide load range with uniform performance. They have a natural frequency of about 7½ cycles per second, with low horizontal stiffness for maximum isolation of horizontal vibration. Transmissibility at resonance is only 4½. There is no snubber contact nor resonance carry-over when ALL-METL Barrymounts are vibrated at government-specified amplitudes.

These mountings are designed especially for unusual military conditions. They meet the vibration requirement of JAN-C-172A, MIL-E-5272 (USAF), and MIL-T-5422 (BuAer). For details of sizes, ranges, and construction of unit mounts and bases using ALL-METL Barrymounts, see catalog 509.

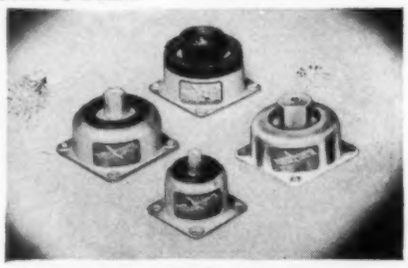
FREE CATALOGS

- 502 – Air-damped Barrymounts for aircraft service; also mounting bases and instrument mountings.
- 509 — ALL-METL Barrymounts and mounting bases for unusual airborne applications.
- 504 — Shock mounts and vibration isolators for marine, mobile, and industrial uses.
- 607 — How to cut maintenance costs by using Barrymounts with punch presses.

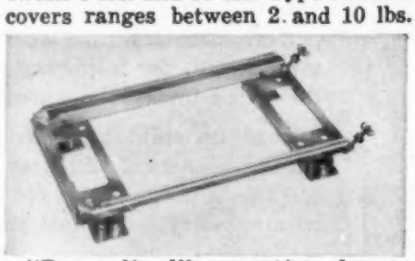
"RUGGEDIZED" BARRYMOUNTS AND MOUNTING BASES

Now Available to Meet Shock Requirements of AN-E-19

Barry vibration isolators and mounting bases are now available in "ruggedized" construction, to withstand the severe shocks of arrested landings in aircraft carrier service and of crash landings. These units are tested to meet the shock-test requirements of Specification AN-E-19, for the equipment sizes listed in JAN-C-172A.



"Ruggedized" Barrymounts are available in both the air-damped type and the ALL-METL type. Air-damped Type 770R covers load ranges between ¼ lb. and 9 lbs. Air-damped Type 780R covers load ranges between 4 lbs. and 35 lbs. ALL-METL Type 6600R covers load ranges between 4 lbs. and 35 lbs. Type M-112R covers ranges between 2 and 10 lbs.



"Ruggedized" mounting bases, equipped with Barrymounts of the above types, are available in standard JAN sizes (JAN-C-172A) and in special sizes to meet customers' requirements. A conspicuous advantage of these "ruggedized" Barry bases is the gain in strength of the base framework itself — beyond JAN requirements — achieved with very little increase in weight for loads up to 60 lbs. by design modification of standard JAN bases. For greater loads, the "ruggedized" Barry bases are of stainless steel instead of aluminum. Write for data sheet.

THE **BARRY** CORP.

722 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

New York Rochester Philadelphia Washington Cleveland Dayton Detroit
Chicago Minneapolis St. Louis Seattle Los Angeles Dallas Toronto

News

OF MANUFACTURERS

A $5,000,000 engineering and construction program is being planned by the **Allis-Chalmers Mfg. Co.** in Terre Haute, Ind. The project will include a 500 by 800-ft manufacturing building and a 50 by 300-ft, three-story office building. In the new plant, to be located on property adjoining North 13th St., north of Terre Haute, the company will manufacture compressors for the J65 Sapphire turbojet aircraft engine under a subcontract from the **Curtiss Wright Corp.**

♦

In order to meet increased demand for its products, **Miller Motor Co.**, Chicago manufacturer of air and hydraulic cylinders, has built a modern, new plant comprising an area of about 50,000 sq ft, at Melrose Park, Ill., a suburb within the Chicago metropolitan area.

♦

Recently organized, the **Admiral Die Casting Corp.** has announced the completion of its modern plant at 200 West 83rd St., Chicago 20, Ill. This new plant is fully equipped with new high-pressure diecasting machines for aluminum, zinc and magnesium die castings. Machining, cleaning, painting and engineering departments are included in the company's facilities for a complete diecasting service from blueprint to finished parts ready for assembly.

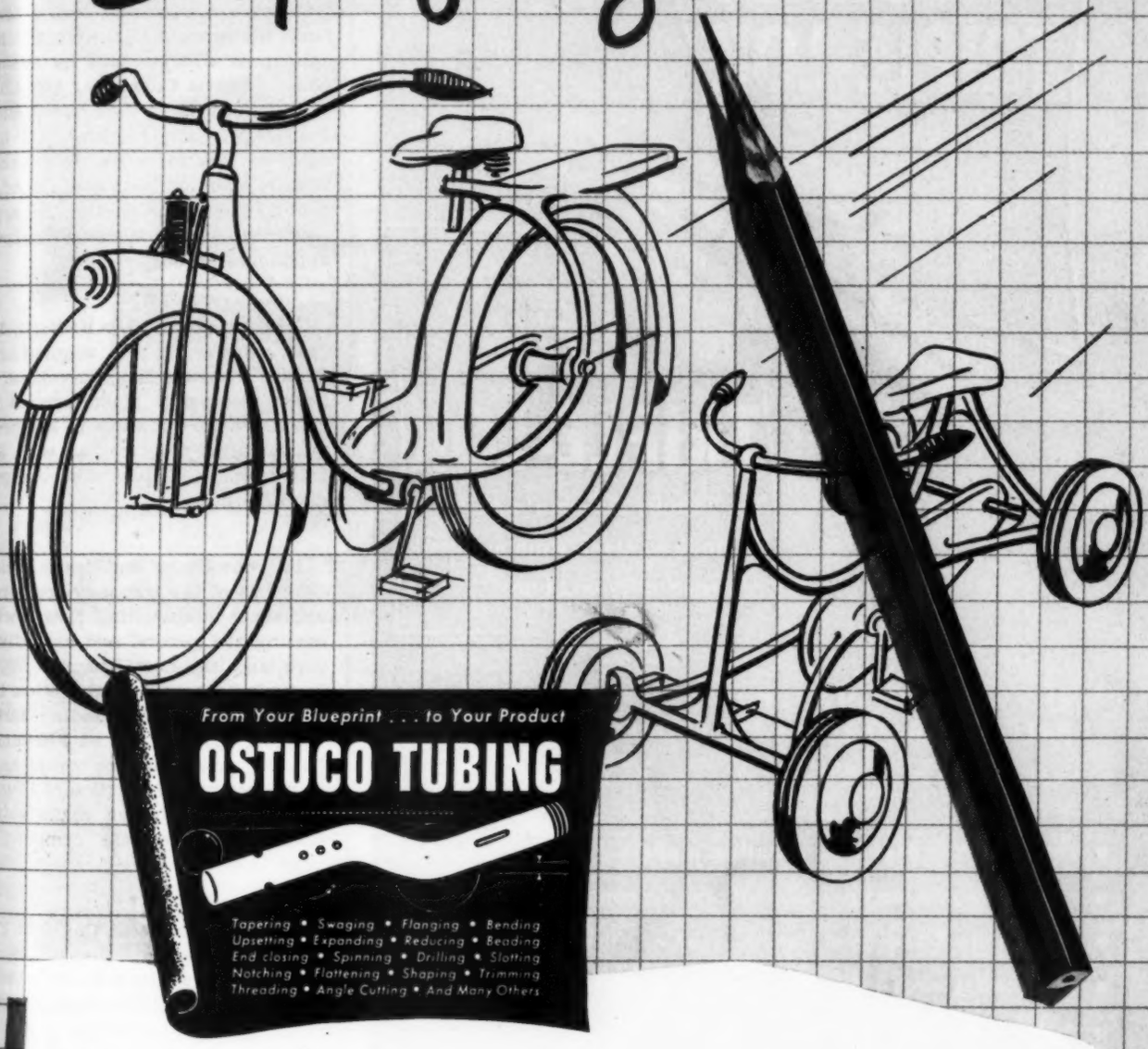
♦

Located on Maple Rd., east of Birmingham, Mich., a new plant and office building has been opened by the **Murray-Way Corp.** The opening of this new structure marks the third expansion step since the firm was founded in 1940. In the new quarters, production of the company's automatic Micro-Polish units will be greatly increased.

♦

An agreement has been concluded between **Calumet and Hecla Consolidated Copper Co.** and the **Karmazin Products Corp.** of Wyandotte, Mich., whereby the Wolverine Tube division of the former company has exclusive rights to produce tubes by the patented Karmazin forming and brazing processes. This exclusive license will substantially increase the scope of the Wolverine Tube division's operations,

Shape of things to Come...



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End closing • Spinning • Drilling • Slotting
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enabling it to manufacture brazed tubes of both ferrous and nonferrous metals in addition to its present line of copper, copper-base alloy and aluminum tubing.

♦

A half-mile long manufacturing plant to be used for the production of jet engine components and, after defense needs are met, for electric home appliances will be built by **Westinghouse Electric Corp.** near the Columbus, O., city line. The new building, the largest single plant yet to be built by Westinghouse, will have 1,900,000 sq ft of floor space, and, following defense production, is expected to increase the division's output of appliances by 50 per cent.

♦

Aerovox Corp., New Bedford, Mass. has announced the acquisition of **Wilkor Products Inc.**, Cleveland. The latter company manufactures precision resistors of value to the present rearmament program, as well as to instrument and precision equipment manufacturers.

♦

To consolidate and house existing branches of the company scattered in and about metropolitan New York, including the general and executive offices and the new Eutectic Welding Institute, a new administration building has been constructed by **Eutectic Welding Alloys Corp.** at Flushing, N. Y. The new structure covers an acre in the Auburndale section of Flushing, adjoining the larger manufacturing plant erected by the company last year.

♦

Ryan Aeronautical Co., San Diego, Calif., has begun construction of a 75,000 sq ft addition to its manufacturing facilities. The factory building is being erected adjacent to the company's large final and subassembly buildings on Lindbergh Field. The new building will provide needed production space for further expansion of Ryan's jet engine components manufacturing program.

♦

Facilities for the molding and extruding of silicone rubber parts have been transferred from the chemical department plant of **General Electric Co.** in Pittsfield, Mass., to the Decatur, Ill., plant of the department, and new equipment has been added that will enable production to be tripled. The centralizing of this silicone rubber fabricating operation will provide improved service to the aircraft, automotive and electrical industry. New extruders and molding

GRAMIX®

bearings carry the load in this "HOME-UTILITY" Drill by Black and Decker

For on-the-job dependability, for long life and trouble free performance, you can't beat this ½-in. "Home-Utility" drill made by Black and Decker, the world's largest manufacturer of portable electric tools. And the big reason for this power-packed quality is found in the GRAMIX bearings that carry the load at six vital points. GRAMIX bearings maintain steady alignment of the drill shafts and absorb the thrust load under hardest operating conditions. Their porous structure is especially important in this application because they can be oil-impregnated during manufacture for self-lubrication, eliminating the need for regular oiling. GRAMIX bearings and specialty parts are precision die-pressed to tolerances within .0005". They are strong and tough, too, and their greater durability and self-lubrication features make for long life in any application. Because they require little or no machining, GRAMIX parts cost considerably less than similar machined parts. GRAMIX can help cut your costs and improve the performance of your product. For complete information write today to —

86

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That is as it should be, of course. But the fact remains that many manufacturers are being confronted daily with knotty problems of production.

Frequently these difficulties can be solved by using substitute grades or alternate methods of manufacture and treatment.

To help you decide *which* substitute grades you can use and *how* you can use them most effectively, call on our staff of metallurgical experts.

A letter – or a phone call – will focus Wheelock, Lovejoy's specialized technical skill and long experience on your individual problems.

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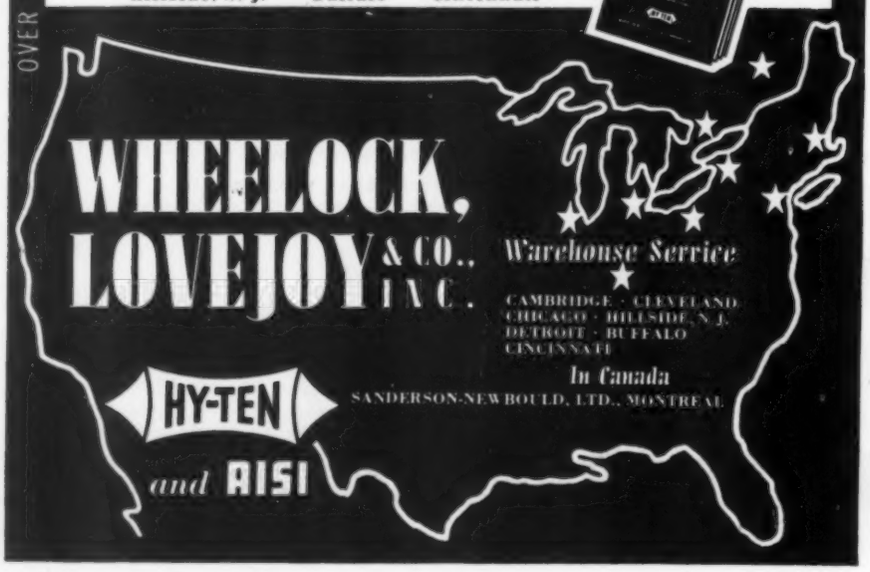


presses will also facilitate the manufacture of larger size parts than have been formerly available from GE.

♦

The Economic Co-operation Administration has awarded to the **United Engineering and Foundry Co.**, Pittsburgh, a certificate of co-operation for furnishing technical assistance to the peoples of the Marshall Plan countries to aid them in maintaining individual liberty, free institutions and peace. Through the sponsorship of ECA, the company has furnished the machinery and techical assistance for the majority of the postwar steel mill installations in various countries in Europe as well as in England.

♦

Rockwell Manufacturing Co. has announced the acquisition of the **Ohlen-Bishop Manufacturing Co.** of Columbus, O. Ohlen-Bishop products augment the line of power tools made by Rockwell's Delta manufacturing division.

♦

Complete facilities for broaching of parts on a job-lot or production basis are now available from **Weaver Broaching Co.** in its new plant at 18515 Weaver St., Detroit 28, Mich. Equipment already installed includes three sizes of horizontal broaching machines designed to handle both internal and surface broaching operations, as well as several types of vertical broaching machines.

♦

Nice Ball Bearing Co., 30th and Hunting Park Ave., Philadelphia, Pa., has recently completed additions to its plant. Manufacturing space will be enlarged by approximately 9150 sq ft, and an addition to be used for the storage of raw materials will cover approximately 5400 sq ft.

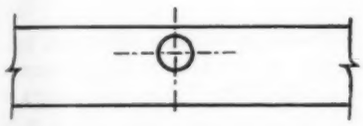
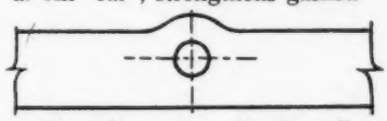
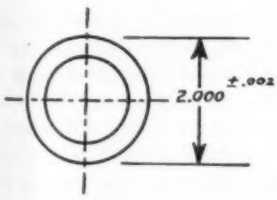
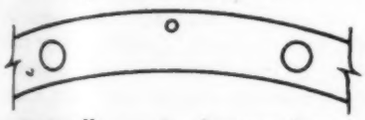
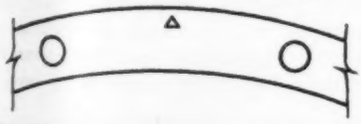
♦

Sponsored by the **Hercules Powder Co.**, the John Wesley Hyatt Award for distinguished achievement in plastics was presented recently to James Bailey, vice president and director of research, Plax Corp., for his research in techniques and invention of machines for the successful extrusion of thermoplastics.

♦

Ground has been broken for construction of an addition to the plant of **National Seal Co.** which will add 40,000 sq ft of manufacturing area to the Van Wert, O., subsidiary of **National Motor Bearing Co. Inc.** Also scheduled for the company's latest expansion are a rubber compounding building and a second floor to the present office building. Production

How to remedy common errors in gasket design

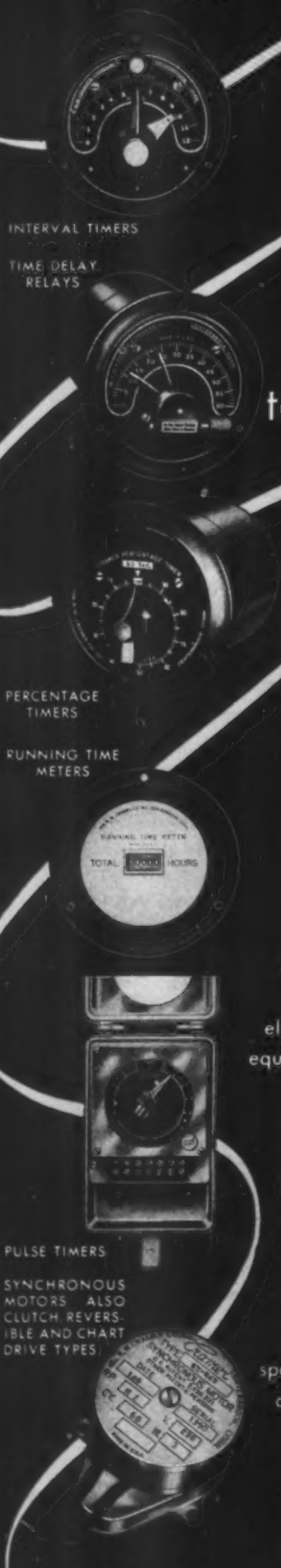
The fault	The reason	The remedy
Bolt holes too close to edge. 	Gaskets so designed are expensive to make as well as expensive to use. They break easily during stripping and center picking and are easily damaged in transit. Often such gaskets also demand careful handling during assembly.	a. An "ear"; strengthens gasket.  b. A notch; removes fragile wall.
Metal-working tolerances applied to gasket thickness, diameter, length, width, etc. 	Close tolerances involve special dies, extra manufacturing operations, and special sorting and inspection. This delays deliveries and increases costs.	Specify realistic tolerances. In most cases, a *resilient* gasket is entirely satisfactory if held no closer than ± .010", even on metal parts that must be held to ± .002". Try standard or commercial tolerances before concluding that special accuracy is necessary.
Very small bolt holes . . .  . or small non-circular openings. 	Centers from such holes probably require hand-picking. Because small holes are easy to miss, extra inspection must be employed. Naturally, this slows down gasket production and increases gasket costs.	Avoid hole sizes under 3/32" diameter. If hole is for indexing or positioning, it may be possible to change to a small notch.

You'll find other helpful information on the design and use of gaskets in "Armstrong's Gasket Materials." This 24-page manual discusses subjects such as designing gaskets to reduce cost . . . designing flanges for efficient sealing . . . the effect of surface condition on gaskets, and many others.

You'll find, too, up-to-date information on Armstrong's various sealing and friction materials. Included are government and SAE-ASTM specifications. See this manual in Sweet's file for product designers. For a personal copy, write Armstrong Cork Co., Gaskets and Packings Dept., 5108 Arch Street, Lancaster, Pennsylvania.

Armstrong's *Gasket Materials*

where dependable timing is essential to product performance . . . consult Cramer



As specialists in TIME as a factor of CONTROL, we have developed a wide range of timing devices, extensively used on electrically-operated commercial and industrial equipment where accurate, dependable timing is essential to insure efficient product performance . . . to add convenience of operation . . . to prevent work spoilage and protect equipment itself.

Although the majority of timing problems can be effectively solved by devices considered "standard" in our line, we have had a great deal of experience in the design of special devices to meet specific requirements . . . and will welcome the opportunity to help solve your timing problem. Write us for complete information.

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will soon begin for a new type fa seal needed in large volume for mi tary equipment and also for tracto farm machinery, washing machin and many other types of machine

♦

Cam-Lok Co., manufacturer welding cable connectors, was recen ly acquired by **Empire Products In** Cincinnati, O. Concurrently, the la ter company announced the buildi of a modern manufacturing plant Rossmoyne, O. Henceforth, the wel ing products company will be know as Cam-Lok, division of Empire Pro ucts.

♦

To meet machinery builders' nee for the 2200 series Frauenthal grin ers, **A. Harold Frauenthal Inc.,** Mu kegon, Mich., is constructing a ne plant which will have an area about 10,000 sq ft.

♦

Precision Welder Mfg. Co. has re cently moved to 660 West Grand Ave Chicago, Ill. The company's ne building provides four times as muc floor space as the former locatio Installation of high-speed equipment plus manufacturing methods, will en able the company to produce six time as many welders as previously.

♦

Scheduled to be completed by mid August, an industrial building is be ing built by **All-State Welding Alloy Co. Inc.** The new structure adjoin the company's home office and plan at 273 Ferris Ave., White Plains, N Y., and will more than double the fac tory area.

♦

A major expansion of engine pro duction capacity, involving new facili ties to cost $6,000,000, is announce by **Cummins Engine Co. Inc.,** Colum bus, Ind. This third major expan sion program within the past nin months will increase production ca pacity at least 50 per cent over th company's 1950 record high level.

♦

West Point Mfg. Co. has move from its former location in Farming ton, Mich., to a new and larger plan at 26935 West Seven Mile Rd., De troit 19, Mich.

♦

Naugatuck chemical division, **Unit ed States Rubber Co.,** recently an nounced a major expansion program aimed at doubling the production o its Baton Rouge, La., Paracril syn thetic rubber plant. Plans call fo the construction of a new adminis tration building and laboratory, as well as new reactors, drying units and

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STABILENE Glass Tracing Cloth, the *dimensionally stable, highly transparent* drawing and reproduction material, has revolutionized production methods.

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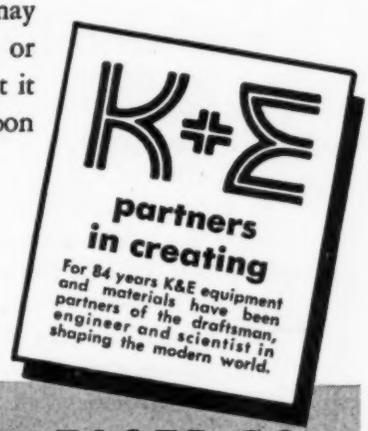
Perhaps STABILENE can help you too. You may have quite different uses for it—comparator work or mapping for instance. But let us tell you more about it and what it is doing for others. Simply mail the coupon below.

* Trade Mark

stability & transparency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How a leather or synthetic rubber VEE PACKING responds to pressure and lives to a tough old age

Vee Packings seldom work alone. They are usually used in sets of 3 to 6, and always with adapters.

Each Vee supports the one ahead: therefore, *all* must be alike in dimension and finish, so that when assembled in sets the lips of each Vee will make uniform contact with the surface to be sealed.

G&K-INTERNATIONAL can meet your requirements in leather or homogeneous synthetic rubber Vee Packings. In *leather* you benefit through quality control that starts with the raw hide and follows through precision manufacturing to the finished packing. In *synthetics*, full laboratory facilities and modern equipment carry the job from formula to final inspection. In *both*, advanced engineering know-how and a stepped-up manufacturing program assure satisfaction.

See G&K-INTERNATIONAL for your packing needs in synthetic rubber compounds or leather. Meeting *your* high standard is *our* business.

For VEE PACKINGS in Grakone (Synthetic) and Leather

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AFFILIATED WITH GRATON & KNIGHT COMPANY

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other production equipment. New warehousing and latex storage facilities will also be added. The expansion program, to be completed early in 1952, will bring plant capacity for the production of Paracril nitrile rubber, Nitrex latex, high styrene latex and high styrene resins to approximately 30,000,000 pounds annually.

♦

Centric Clutch Co., maker of Rawson centrifugal clutch-couplings, has moved into its newly completed building in Woodbridge, N. J. The new plant provides four times as much space as the company's former facilities at Cranford, N. J.

♦

The purchase of 200,000 sq ft of manufacturing space in Birmingham has been announced by the **Essex Wire Corp.** This building is located on 14 acres of property which can be used for future expansion.

♦

The new electron tube manufacturing plant in Cincinnati, to be devoted exclusively to the production of miniature and subminiature tubes, was opened recently by the **Radio Corp. of America.** The new one-story plant occupies a tract of 17 acres and contains 136,000 sq ft of floor space.

♦

Buchanan Electrical Products Corp. has recently moved its entire facilities to a new modern plant located at 225 Highway 29, Hillside, N. J. The new building, which houses general offices as well as experimental, engineering and production departments, provides three times the floor space of the company's previous location and will allow immediate expansion of production capacity.

♦

The Buffalo branch of **The American Brass Co.** has recently completed a mill improvement program in its sheet and strip brass department. The mill is now capable of producing long coils of strip brass up to 24-in. wide, rolled from 3300-lb castings, as compared with a previous maximum weight of about 250 lb.

♦

Aeroquip Corp., manufacturer of flexible hose lines, self-sealing couplings and other components used on aircraft and numerous industrial products, recently put into operation its new Burbank, Calif., plant, thereby completing an extensive expansion program. The new Burbank plant is operated by **Aero-Coupling Corp.,** an Aeroquip subsidiary. Other important expansion moves recently completed include the addition of a new 65,000 sq ft building to the company's

main plant in Jackson, Mich., and the acquisition of another subsidiary, **Metalco Inc.**, with a plant in Cheboygan, Mich.

♦

Reopening of the world's largest rubber plant, a government-owned facility at Institute, W. Va., has been completed, according to a recent announcement from **B. F. Goodrich Chemical Co.** All production lines at Institute are now operating slightly above their rated capacity of 90 000 long tons of rubber annually.

♦

Sierra Electronic Mfg. Co. is the name of a new production organization established at 1050 Brittan Ave., San Carlos, Calif. It is related to the established developmental company, **Sierra Electronic Corp.**

♦

Construction of new general offices and plant facilities for the **Crane Packing Co.** of Chicago is now under way. The new plant site, situated on Oakton Ave. near Lehigh in Morton Grove, Ill., will cover 133,000 sq ft when completed and will provide for increased production of packings and seals to meet present day requirements in the wide range of temperatures, speeds and services for national defense.

♦

Periflex Inc., formerly Platen Products Co., has announced the change of the company name to coincide with the tradename of its hydraulic and pneumatic packings.

♦

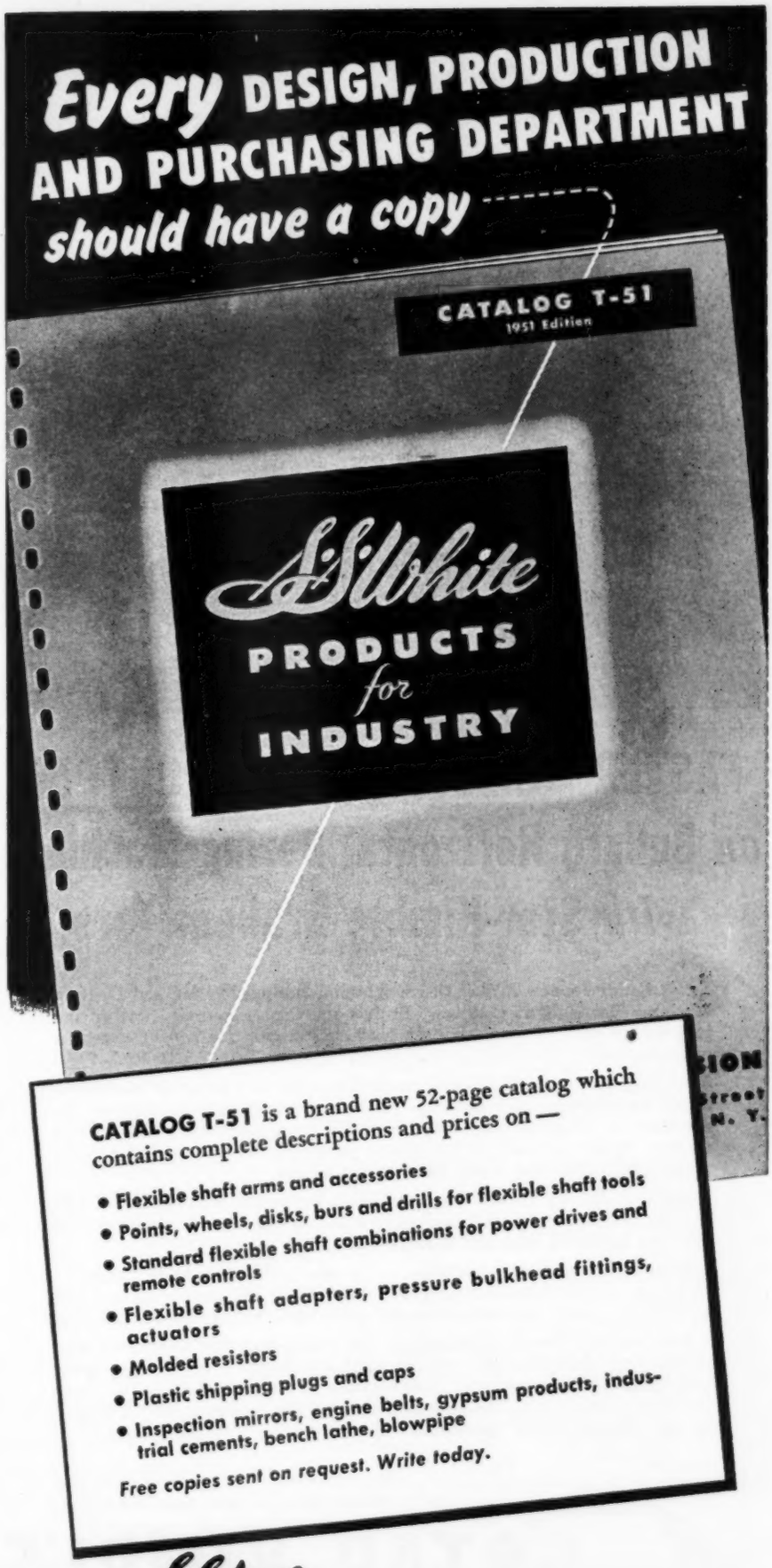
Plans for the immediate construction of a large new plant addition have been announced by Republic Rubber division, **Lee Rubber & Tire Corp.**, Youngstown. The new 80,000 sq ft addition and its equipment will be used for the production of wire and textile braided, mandrel built, lead press cured hose. The company hopes to begin manufacturing in the new plant within a year.

♦

Announcement of the completion of the new **Farr Co.** main factory and office building in El Segundo, Calif., has been made. With a floor area of approximately 50,000 sq ft, the new plant has more than double the manufacturing area of the former factory in Los Angeles.

♦

The **Allegheny Ludlum Steel Corp.** has been granted a license by **Armco Steel Corp.** to use certain of its processes in connection with the production of special electrical steels. The patents concerned apply principally to the manufacture of grain-oriented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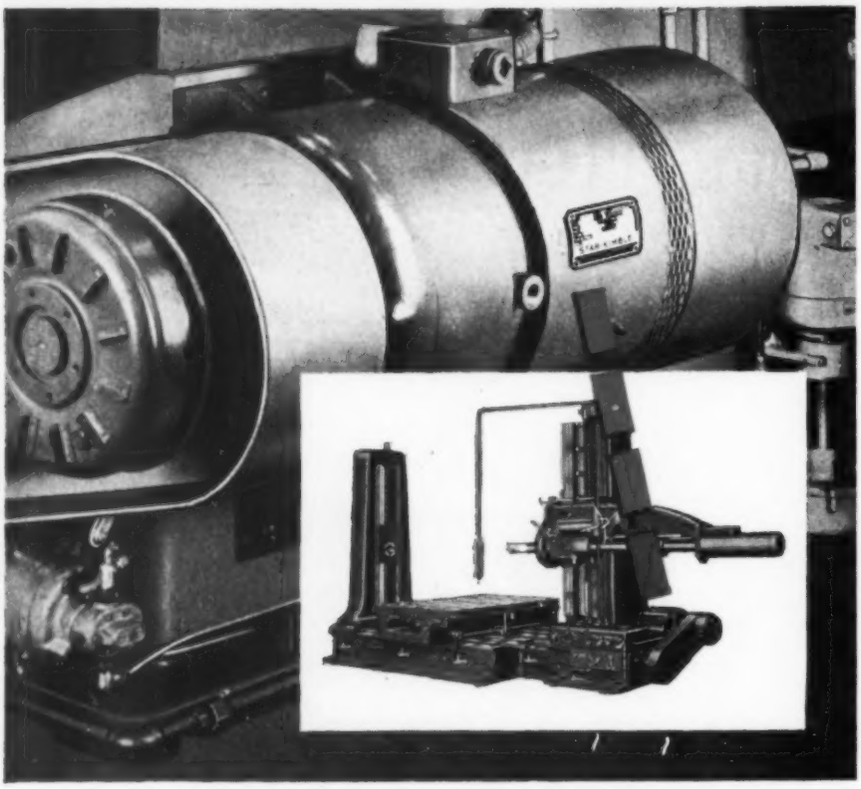

FASTER SET-UP... HIGHER OUTPUT *on* Bullard Horizontal Boring Machines *with* Star-Kimble Brakemotors

In designing its new 4-Way Bed Horizontal Boring, Milling and Drilling Machine, The Bullard Company, Bridgeport, Conn., naturally was on the lookout for ways of *increasing* the machine's output and *cutting down* its operating cost.

Setting-up of the machine—and production runs, *too*, in many instances—called for frequent starts-and-stops. Conventional methods of stopping the machine, by plugging the motor, held the start-stop cycle down to 6 a minute—heater elements in the motor starter kicked out at that point—production was stalled while the elements cooled.

Then . . . Bullard switched to Star-Kimble Brakemotors to handle the job. *Result:* as many as 30 starts-and-stops a minute are now possible without affecting the heater elements in the control.

How is this possible? *Because* . . . in this application, as in thousands of others . . . the *large* disc area of a Star-Kimble Brakemotor assures fast *stopping* . . . the *small* air gap assures quick brake release for fast *starting*.

Like *all* Star-Kimble Brakemotors, the totally-enclosed, fan-cooled ones installed on these Bullard machine tools are integral, space-saving units consisting of motor and brake *built* together to *work* together . . . *designed* for their specific job by the pioneer makers of disc brakemotors . . . *backed* by more than 25 years' application experience.

For full information on construction and ratings, write for free Bulletin B-501-A.

STAR-KIMBLE

MOTOR DIVISION OF
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201 Bloomfield Ave. Bloomfield, New Jersey

silicon iron alloy steels, including newly developed electrical steels with special properties. These electrical steels, largely used in the production of transformers, generators and other electrical equipment, are also finding extensive use in new and improved military equipment.

♦

Marman Products Co. Inc., Inglewood, Calif., announces construction of a new plant to increase its capacity by 300 per cent. Producing engineered clamps, strips and couplings, the company is a supplier to aircraft and other basic industries.

♦

Construction of a new addition to the plant of **The H. M. Harper Co.**, Morton Grove, Ill., manufacturer of nonferrous and stainless steel fastenings, was recently begun. Scheduled for completion late this year, the new building will increase total floor space to 166,000 sq ft and will house complete facilities for the reduction of copper, nickel, aluminum and stainless steel wire and bar stock. Equipment will include light and heavy draw benches for bar drawing and a battery of wire drawing machines for wire up to ¾-in. diameter. In addition, complete annealing, descaling, pickling and coating equipment will be installed.

♦

The **Tube Reducing Corp.**, Wallington, N. J., recently added Westin process machines to its equipment in order to give customers the advantages and economies that result from being able to size and form the ends of close tolerance tubing all in one plant.

♦

Berry Motors Inc., of Corinth, Miss., recently merged into the **Oliver Iron and Steel Corp.** and hereafter will be known as the Berry division of Oliver Iron and Steel Corp. The Berry division will continue to manufacture its patented motors and industrial transmissions at the Corinth plant. The Oliver corporation, manufacturer of industrial fasteners and small forgings, has been in continuous operation since it was founded in 1863. The addition of its new division will give the company a more diversified group of products and a stake in the fast-growing hydraulic industry.

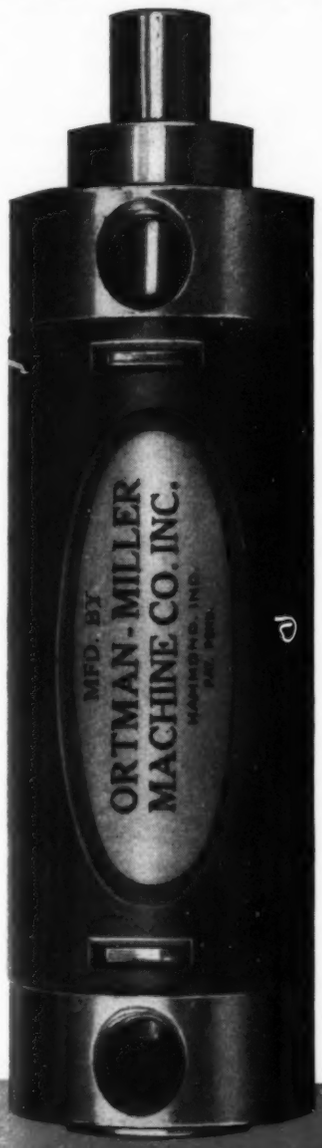
♦

Because of increased demand for its products, the **Wel-Met Co.** is planning construction of an additional plant at Salem, Ind. The new plant will triple the company's production of self-lubricating bearings and structural and mechanical parts made of sintered metal powder.

YOU GET

PROMPT DELIVERY plus*...

WHEN YOU SPECIFY O-M CYLINDERS



* MORE POWER IN LESS SPACE AT LOW COST

—as provided by these talked-about features:

Compact Performance

Simplified design eliminates tie-rods and bulky end caps. Saves up to 1/3 space when installed.

Flexible Performance

Interchangeable mounting brackets may be fitted without disassembly. Pipe Ports adjustable to any angle. Easily disassembled and re-packed.

Low Cost Performance

Lower first cost . . . smaller inventory . . . minimum maintenance.

FREE TEMPLATES

For the first time in the industry, O-M offers a complete set of templates showing all cylinders and mounting brackets. ½ scale. Your set on request.

O-M manufactures:

- **Air**
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Cylinders

In full range of sizes from 1½ to 8" bores. All machined steel and bearing bronze.

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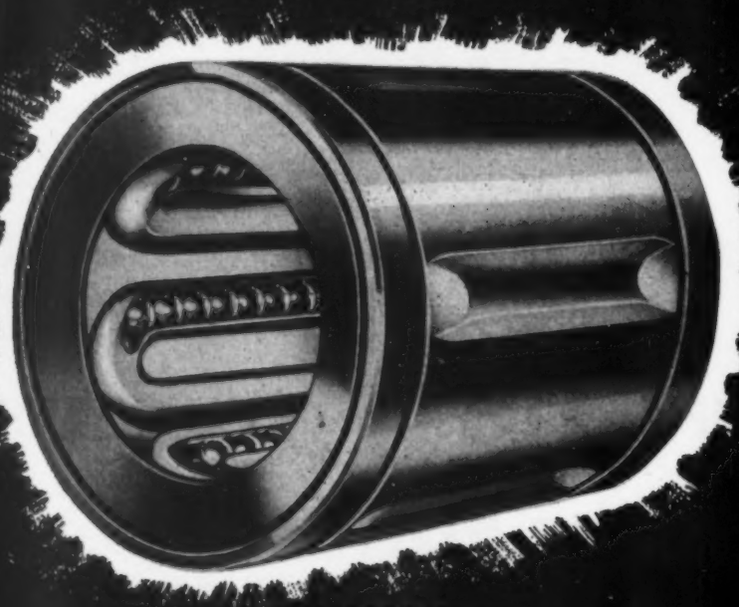

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LINEAR MOTIONS

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Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product. Up-date your design and engineering with BALL BUSHINGS!

LOW FRICTION • LONG LIFE
ELIMINATES BINDING AND CHATTER
SOLVES SLIDING LUBRICATION PROBLEMS
LASTING ALIGNMENT • LOW MAINTENANCE

Now manufactured for 1/4", 1/2", 3/4", 1" and 1 1/2" shaft diameters.

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PROGRESSIVE MANUFACTURERS USE BALL BUSHINGS—
A MAJOR IMPROVEMENT AT A MINOR COST

Society
ACTIVITIES

AT THE recent annual meeting of the **Malleable Founders' Society**, Cal C. Chambers, Texas Foundries Inc., was elected president of the Society for the coming year, and F. D. Brisse, Laconia Malleable Iron Co., was elected vice president. New directors are G. T. Boli, Northern Malleable Iron Co.; R. N. Hoffman, Michigan Malleable Iron Co., W. H. Moriarty, National Malleable and Steel Castings Co.; and Mr. Brisse.

♦

Henry M. Richardson, DeBell & Richardson, chairman of the **Society of Plastics Engineers Inc.**, prize paper contest committee, has announced that Carl J. Frosch of Bell Telephone Laboratories will serve as chief judge in the third annual SPE contest, for which entries are now being received. The contest is designed to encourage the younger members of the Society in the preparation of technical papers contributing to the advancement of the plastics industry. The contest will be conducted first on a local, and subsequently on a national basis. All entries are to be submitted to the section officers. Deadline for the submission of entries to the sectional contests is October 15, 1951. Complete details may be obtained from Society of Plastics Engineers Inc., 409 Security Bank Bldg., Athens, O.

♦

By action of the board of trustees of the **American Society for Metals**, Dr. Zay Jeffries of Pittsfield, Mass., retired vice president of the General Electric Co., a past president of the ASM, author, scientist and a member of the National Academy of Sciences, has been appointed director general of the World Metallurgical Congress. Dr. Jeffries will help shape the program of the Congress, which is being sponsored by the ASM and which will be held in Detroit, October 14-19.

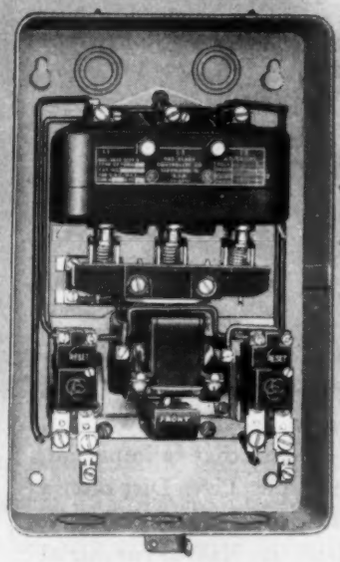
♦

The **Gas Appliance Manufacturers Association** recently announced that designers and builders of more than 25,000 different types of gas equipment for industrial use have announced voluntary adoption of a "code of ethics" governing the standards of performance and safety of such equipment. These manufacturers, who make gas equipment used in automotive, metals, textile and other

Setting new standards in starter performance

The CLARK TYPE "CY" AC MAGNETIC MOTOR STARTERS with the NEW ARC QUENCHING PRINCIPLE

- No tools needed to inspect contacts. Contacts, coils, and stationary magnet frame easily removed.
- Melting alloy-type overload relays.
- Vertical lift clapper type magnet adapted to straight line guided movement, uses no springs.



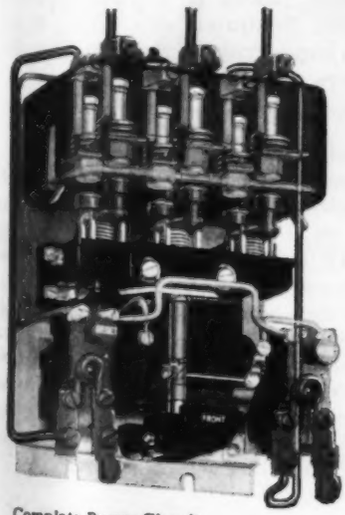
These rugged magnetic starters provide the extra protection and dependable operation of "Mill-Type" heavy-duty construction and design.

another CLARK first!

The CLARK Type "CY" Starters feature the combined use of strong multi-turn magnetic blowouts with twin-break contacts.

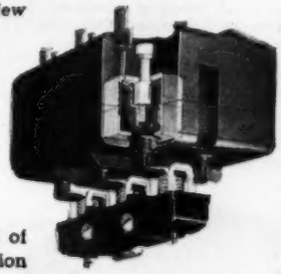
The Type "CY" starters employ an entirely new principle of arc interruption. The blow-out coils are concentric with the contacts. The magnetic field quenches the arc either by lengthening or confining it. By forced rotation the arc moves continually from a hot to a cold spot—minimizing burning or pitting of contacts. The solid upper arc shield prevents the accumulation of hot gases between wiring terminals—minimizing phase-to-phase failures*.

All parts in the arc chamber are copper, brass and steel, thus preventing carbonization. Absence of carbon and soot means longer contact life and lower operating temperatures.



Complete Power Circuit of CLARK Type "CY" Starter, Size 2

Phantom View Showing Arc Shield



*Magnetic blow-out coils are used on all size 2 and 3 Type "CY" starters. Mill-Type construction is used on sizes 0 and 1.

Let a CLARK application engineer show you what this new line of CLARK Type "CY" starters means to you in increased production and lower maintenance.

THE CLARK CONTROLLER CO.

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always the right connection

between driving and driven units . . .

Wherever you find horsepower at work, you will find Twin Disc Clutches and Hydraulic Drives.

That's because Twin Disc offers *standard* units for every kind of application in the industrial field, from split-second work cycle operations to 1000 hp tugs-of-war between prime movers and mother nature.

Thirty-three years of working with hundreds of leading equipment manufacturers have proved that, no matter the problem, Twin Disc can help provide the answer.

And an answer that is impartial, for not only does Twin Disc offer a complete line of friction clutches, it offers a complete line of industrial fluid drives as well.

That's why for the *right connection between driving and driven units,* always specify Twin Disc.

for example

Twin Disc's Model CL Clutch is a compact husky, known wherever construction equipment is used. Three Model CL Clutches are employed in this Cedar Rapids "Rock-It" plant, operating under severest conditions. Model CL Clutches are offered in one, two and three-plate construction in 5½ to 11½ inch models. Ample safety factors insure long trouble-free wear life. Single point adjustment is made from the outside of the clutch without the use of any tools.

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CLUTCHES AND HYDRAULIC DRIVES

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essential production, have pledged themselves to a code governing such items as product design based on sound engineering principles and proved research, employment of superior workmanship and materials, design and construction with a view to satisfactory product performance over a reasonable expected lifetime, readiness to co-operate in the preparation and application of official standards, when and if promulgated by the American Standards Association, and application of highest standards of safety and durability to the selection of controls and accessories used in finished products.

•

Awards have been presented to members of the board of directors and standards council of the **American Standards Association** who have served more than a year. Certificates of service were given in recognition of their work in the development of American standards. Maurice Stanley, Fafnir Bearing Co., representing The Anti-Friction Bearing Manufacturers Association on ASA's board of directors, was among those honored. Members of the standards council representing associations in the machinery field similarly honored are George P. Byrne, Industry Service Bureaus, representing the U. S. Machine, Cap, Wood and Tapping Screw Bureaus; Alton G. Knight, Hendey Machine Co., representing the National Machine Tool Builders' Association; Harry B. Lindsay, Grinding Wheel Institute; and H. O. Smith, The Anti-Friction Bearing Manufacturers Association.

•

Samuel G. Hibben, director of applied lighting for Westinghouse Electric Corp., has been elected president of the **Illuminating Engineering Society,** one of the highest professional honors anyone allied with good lighting can achieve. IES members represent utilities, lamp manufacturers, lighting equipment manufacturers, college faculties and students, government groups, eyesight specialists and others interested in fostering good lighting practices.

•

At the 54th Annual Meeting of the **American Society for Testing Materials,** the following officers were elected: President, elected for a one-year term, Truman S. Fuller, General Electric Co.; vice president, for a term of two years, Leslie C. Beard Jr., Socony-Vacuum Oil Co. Inc.; and members of the board of directors, elected for a three-year term, John W. Bolton, The Lunkenheimer Co.; Rudolph A. Schatzel, Rome Cable

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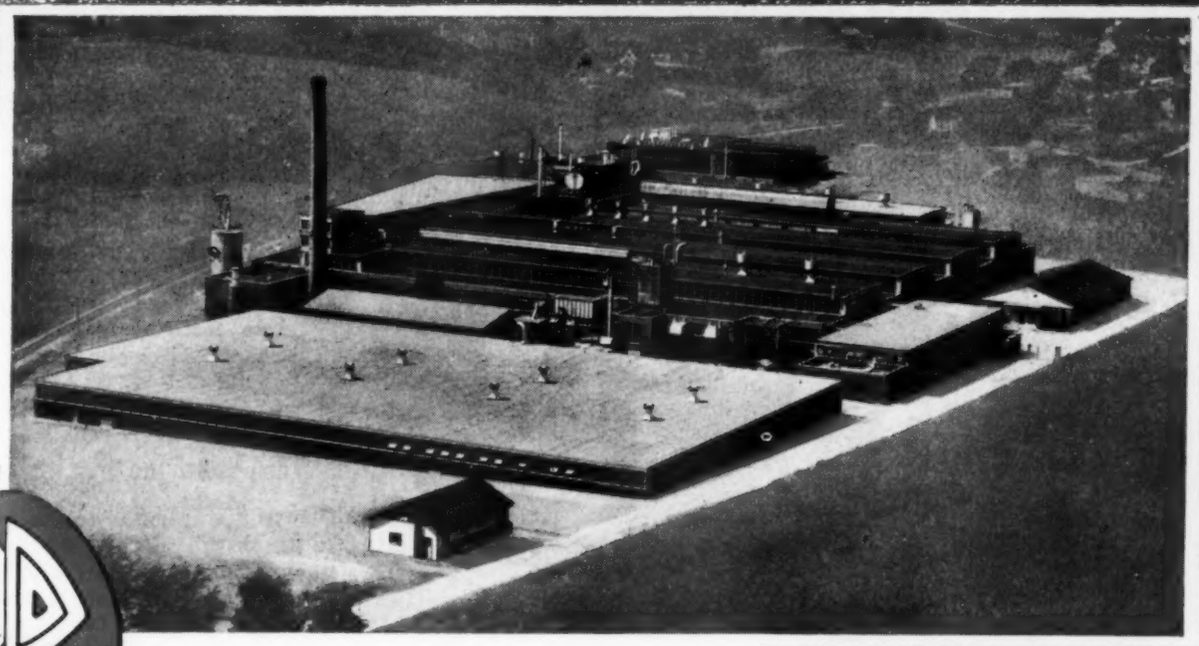

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Here at Aluminum Industries, Inc., are proven facilities you can count on for supplying aluminum alloy castings of uniformly high quality, in any sizes and in any quantities you need. Just check and compare:

- One of the largest aluminum foundries in the United States for the production of Permanent Mold, Semi-Permanent Mold and Sand Castings.
- Ample capacity for immediate scheduling of your requirements.
- Well-equipped department for machining and finishing aluminum castings.
- Tool room, equipped with the latest type machine tools.
- Physical and metallurgical laboratory, equipped to maintain strict quality control and inspection standards.
- Pattern shop for pattern repair and maintenance.
- Engineering Department for application of the best engineering principles, all the way from the design stage to the finished casting.
- Ample warehousing facilities, favorably located for shipping.
- Secondary aluminum plant for the refining of scrap metals.
- Foundry personnel with the skill and "know-how" developed in over 30 years of experience in working with aluminum and its alloys.

Send for new bulletin telling how and why you can depend upon Aluminum Industries, Inc., for the aluminum castings you need in your production. Ask for Bulletin No. 20-A. Recommendations and estimates given without obligation.

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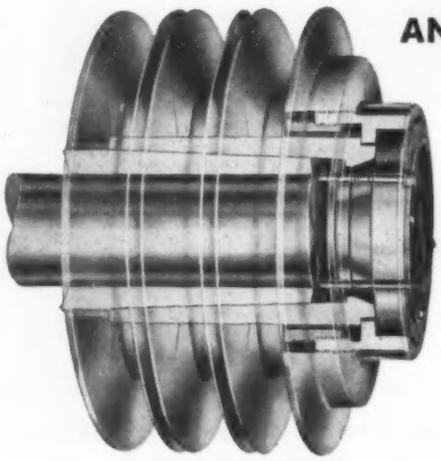
ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

Only AMERICAN WEDGBELT® SHEAVES give you the advantages of TAPER-BUSHED HUBS

ON BOTH

Multiple-Groove Fixed-Pitch Sheaves

AND



Multiple-Groove Adjustable-Diameter Sheaves

Only American Wedgbelt Sheaves give you the advantages of *quicker assembly, easier breakaway* yet *maximum clamping action* in *both* fixed-pitch *and* adjustable-diameter multiple-groove sheaves.

Assembly is quicker because of one-piece, accurately-machined bushings—breakaway is easier because of the exclusive "perfected taper" of American Wedgbelt bushings—maximum clamping action is assured because the bushings are *split all the way* through. In addition, precision manufacturing assures accurate, long-wearing grooves and balanced vibration-free operation.

Look to American as your source of supply for *all* V-belt drive products: Taper-bushed Standard Wedgbelt Sheaves, Double-Taper Adjustable-Diameter Wedgbelt Sheaves, F.H.P. Sheaves and F.H.P. and Multiple Wedgbelts. Mail the coupon below for full information on the complete line of American Wedgbelt Drives.

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Please send me information on American Wedgbelt Drives.

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COMPANY_____

ADDRESS_____

CITY_____ STATE_____

Corp.; E. O. Slater, Smith-Emery Co.; Stanton Walker, National Sand and Gravel Association; and F. P. Zimmerli, Barnes - Gibson - Raymond Division of Associated Spring Corp. Also at this meeting ASTM Awards of Merit were presented to a number of men who have rendered service to the Society, particularly in its technical committee work. This group includes William Blum, National Bureau of Standards; Hyman Bornstein, Deere and Co.; Robert Burns, Bell Telephone Laboratories Inc.; Harry Van Osdall Churchill, Aluminum Co. of America; and Carl DeWitt Hocker, Union College. Authors of outstanding technical papers presented at previous meeting of the Society also received awards during the annual meeting. The Charles B. Dudley Medal was presented to Professors D. S. Clark and P. E. Duwez, California Institute of Technology; the Richard L. Templin Award, to R. L. Templin and W. C. Aber, Aluminum Co. of America; and the Sam Tour Award, to C. T. Evans Jr., The Elliott Co.

♦

At the Annual Summer Meeting of the **Institute of the Aeronautical Sciences,** Lt. Col. Marion Eugene Carl, U.S.M.C., Head, Carrier Aircraft Section, Flight Test Division, Naval Air Test Center, Patuxent River, Md., received The Octave Chanute Award for 1951. The certificate of award is presented annually for a notable contribution made by a pilot to the aeronautical sciences. At the same time, Dr. John Burlin Johnson, Head, Metallurgy Group, Office of Air Research, received The Thurman H. Bane Award for 1951. This award is presented annually to an officer or civilian of the Air Materiel Command for outstanding achievement in aeronautical development.

♦

The **National Association of Fan Manufacturers** has elected John M. Frank as president for the coming year. Mr. Frank is president of the Ilg Electric Ventilating Co., Chicago.

♦

At its recent annual meeting in Washington, D. C., the **Acoustical Society of America** paid tribute to the National Bureau of Standards. During the meeting, attended by more than 200 physicists, engineers and architects, the Society's president, Professor Philip M. Morse, presented a scroll to Dr. E. U. Condon, NBS director, in commemoration of the Bureau's semicentennial. The scroll contains congratulations to the Bureau, praising and commending its research, service and co-operation with others in the science of acoustics.

WOLVERINE COPPER TUBING *first* ON D.O.

but we're not forgetting YOU

Copper and copper base alloy tubing is specified on many Defense Orders. Wolverine tubing is often selected because it is, as you know, quality-controlled from ore to finished product and, therefore, conforms to the high standards that must be met.

Incidentally, Wolverine has been manufacturing copper and copper base alloy tubing for well over thirty years.

But like all other manufacturers, we are cognizant of the division of our obligations. Your needs, too, are recog nized. Not all the copper tube we produce daily is earmarked for emergency use. The maximum percentage allowed by government regulations is being produced to take care of essential domestic needs—your other needs.

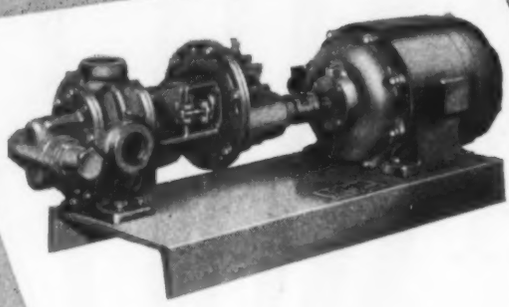
Whatever tube you can get, utilize it to the best advantage. Employ it judiciously and we shall all get along very well until the emergency is over.

WOLVERINE TUBE DIVISION
Calumet & Hecla Consolidated Copper Company
INCORPORATED
Manufacturers of seamless, non-ferrous tubing
1433 CENTRAL AVE. • DETROIT 9, MICH.

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
Sales Offices in Principal Cities

Export Department, 13 E. 40th St., New York 16, N.Y.

EFFICIENCY + PLUS



THE DEPENDABLE **ROPER**

FOR GENERAL PURPOSE PUMPING

What do you expect of the pumps you install? Efficiency, dependability, endurance, simplicity, an unusually high record of performance? If these are your requirements, by all means investigate the Roper 3600 Series; pumps that are engineered to do a wide range of jobs handling both thick or thin clean liquids.

At this very moment the interests of tank truck operators, refineries, bulk stations, process plants and general industries are being served by thousands of Ropers. The size for your needs can do an equally productive job for you!

OUTSTANDING FEATURES...OUTSTANDING PERFORMANCE

Pumping liquids from A to Z calls for quality-made components accurately assembled. Series 3600 pumps feature hardened helical pumping gears; heavy duty, high-lead bronze bearings; adjustable relief valve (from 20 to 90 P.S.I.); split packing gland; one-piece case of practical design. Standard or special fitted models available. Pressures to 60 P.S.I. — capacities 40 to 300 G.P.M.

Send Today For
"HOW TO SOLVE PUMPING PROBLEMS"

FREE ON REQUEST

SEE OUR CATALOG IN SWEET'S

ROPER Rotary Pumps

GEO. D. ROPER CORP.
248 Blackhawk Park Ave.
ROCKFORD, ILLINOIS

SALES AND SERVICE

Personnel

FORMERLY a field engineer in the Chicago district office, **Harry Nowicki** has been appointed to the position of district manager of the eastern Texas division of Ampco Metal Inc., Milwaukee. His headquarters will be in Houston, Tex. **Sam Coddington,** Wisconsin district field engineer, has been transferred to the Chicago district to replace Mr. Nowicki.

♦

Synthane Corp., Oaks, Pa., manufacturer and fabricator of laminated plastics for industry, has appointed **Warren C. Stokes** to its Milwaukee district sales office as assistant to **Howard A. Tyner.**

♦

William J. Thomas, general sales manager of The Babcock & Wilcox Tube Co., Beaver Falls, Pa., has been named to the tubing industry advisory committee, which functions under the Office of Price Stabilization. Mr. Thomas has also been named to the welded and seamless steel tubing industry advisory committee, which functions under the iron and steel division of the National Production Authority.

♦

To serve the northern half of New Jersey, **Richard A. Kelting** has been named manager of the new Newark, N. J. sales office of The Falk Corp. Mr. Kelting has been associated with the Falk sales office in New York for 18 years.

♦

Formerly general manager at Litton Industries, **Leonard V. Bedell** has become general manager of Sierra Electronic Manufacturing Co., producer of electronic dynamic pressure-measuring equipment, and vice president of Electronix Engineering Associates Ltd., application-engineering representative for Sierra products.

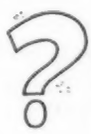
♦

David R. Grossman & Co., factory agent, industrial distributor and export agent for a varied line of ball and roller bearings, has announced that **Eugene E. Gloss,** director of sales, has joined the National Production Board, resuming his World War II position as chief of the bearings section. Mr. Gloss has had ex-

give "Mr. Tubes" a closer look at these ORDER DATA to get: improved service and material economy

Carbon, Alloy and Stainless steel tubes are defined under CMP regulations as "controlled materials". As such, they are critical materials. Not being a mind reader, "Mr. Tubes"—your B&W Tube Company representative—needs a *close* look at the following facts in order to supply the available tubing most economically suited to your requirements.

1 All related CMP authorizations and government contract numbers.



2 Any acceptable alternates in type, finish, composition, and size.

3 A brief, informative description of your intended fabricating methods.

4 A description of the end-use, exact as to product and its service.

THE BABCOCK & WILCOX TUBE COMPANY

Executive Offices: **Beaver Falls, Pa.**

General Offices and Plants

Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

Sales Offices: Beaver Falls, Pa. • Boston 16, Mass. • Chicago 3, Ill.
Cleveland 14, Ohio • Denver 1, Colo. • Detroit 26, Mich.
Houston 2, Texas • Los Angeles 15, Calif. • New York 16, N. Y.
Philadelphia 2, Pa. • St. Louis 1, Mo. • San Francisco 3, Calif.
Syracuse 2, N. Y. • Toronto, Ontario • Tulsa 3, Okla.

B&W SEAMLESS and WELDED TUBES

TA-1640-G

Inside the plywood shipping cases of Burroughs Typewriter Accounting Machines you will find a brand new kind of protection against damage from accidental dropping and rough handling. Each machine is supported by four LORD Shipping Mounts which cushion shock forces with the controlled softness which only shear-type rubber mountings can provide. Their ability to prevent exposure of the machine to excessive shock forces in all planes insures maximum protection, regardless of the position in which the case may fall.

Extensive tests during the period in which Burroughs Adding Machine Company was considering the use of this new system indicated that LORD Shipping Container Mounts enable a packaged machine to be dropped over 36 inches without damage. The value of such high-quality protection was proved by over 1000 foreign shipments to date which have been delivered in perfect condition . . . without a single loss from breakage.

If you encounter frequent shock damage to shipments . . . if service costs are high at destination . . . if you wish to insure arrival of your products with factory-set adjustments intact — you should investigate LORD Shipping Mounts. Write for complete information . . . see how this new method can cut your shipping losses.

1. Insure safe arrival of shipments through *engineered* shock mounting design and application.
2. Enable many products to be shipped completely assembled and accurately adjusted.
3. Reduce cost of servicing and parts replacement at destination.
4. May be reused many times.
5. Eliminate need for storage of bulky, inflammable packing materials.

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

Vibration-Control Mountings . . . Bonded-Rubber Parts

tensive experience in the ball bearing industry, having worked for the New Departure Co. for more than 15 years and having been with Grossman & Co. for several years.

•

I. F. Thomas has been appointed manager of the newly established western district office of the S. S. White industrial division. He will be located in the Times Bldg., Long Beach, Calif., and will handle all activities in connection with the company's flexible shafts, resistors, valves for compressed gases, plastic products and aircraft accessories in the northwestern, southwesten and far western states.

•

Associated with the firm for ten years, **J. S. Munro** has been named assistant general manager of The Canadian Raybestos Co. Ltd., Peterborough, Ontario.

•

Previously vice president and general manager of both divisions, **W. B. Caldwell** has been elected president of the Calumet Steel division, Chicago Heights, Ill., and the Franklin Steel division, Franklin, Pa., of Borg-Warner Corp. Prior to Mr. Caldwell's election, **Roy C. Ingersoll**, president of Borg-Warner, had also held the presidency of the two divisions.

•

Coincident with the anniversary of his thirtieth year with the company, **N. J. MacDonald,** vice president in charge of sales, was appointed to the new post of vice president in charge of all operations of the Thomas & Betts Co., Elizabeth, N. J.

•

Federated Metals Division, American Smelting and Refining Co., has announced the appointment of **A. E. Buchanan** as sales representative to cover the territory which includes North and South Carolina, the eastern half of Georgia and all but the extreme western part of Florida.

•

George C. Rodgers and **Irving W. Clark** have been named managers of the respective military sales departments of the American Air Filter Co. operations in Moline, Ill. and Louisville, Ky. Mr. Rodgers will manage the military sales department of the Herman Nelson division in Moline, where the company manufacturers portable heaters and ventilators and other heating and air handling equipment, as well as specially designed portable heating devices used for air-

Quality control...

another feature of Accurate service

A portion of the elaborate quality control equipment in use at Accurate.

. . . and it lowers

the overall cost of your springs

THE uniformly high quality of Accurate springs . . . their rigid adherence to the customers specifications . . . are the natural result of the combination of skilled springmakers and the most modern springmaking machines *plus* painstaking quality control procedures. Quality control is just one of the features of Accurate service. Certainly, we could "get by" without it like so many other spring manufacturers do. But we have found it pays off handsomely for our customers *and* ourselves. The customer gets uniformly good springs with savings in time and money because there are fewer rejects and assembly runs more smoothly. We come out ahead because our customers are pleased and we're not subjected to a flood of substandard "returns." In the overall, it means lower costs for everyone.

The best way to find out what we mean is to give us a trial. For a quotation just send a drawing and specifications or, if you prefer, Accurate engineers will be pleased to give their assistance in developing new or improved design. ACCURATE SPRING MFG. CO., 3813 W. Lake St., Chicago 24, Illinois.

Write for your copy of the new revised Accurate Handbook of Technical Data on Springs. This booklet has been out of print for some time and if you have previously requested a copy and have not received it, we would appreciate your asking again.

Be sure the springs you buy are Accurate

Accurate Springs

Springs
Wire Forms
Stampings

HYDRECO Oil Hydraulic Gear PUMPS

PAY OFF WHERE THE GOING IS TOUGH

Bulldozers and all types of earth-moving equipment normally operate under conditions imposing heavy mechanical and hydraulic loads on the hydraulic system. American Tractor and Equipment Company uses HYDRECO 3000 Series Pump on their Model TD14W Heavy-Duty Dozer. Like many other heavy-duty equipment manufacturers, ATECO knows that HYDRECO Pumps are made to take abuse. Look at the cutaway view . . . note the simple design — large area roller bearings — sturdy spur gears — high pressure oil seal — renewable wear plates — and most important of all, the four-bolt construction. HYDRECO Four-Bolt design locates the assembly bolts close within the area of greatest internal pressure, insuring rigidity and stability that cannot be equalled. HYDRECO Four-Bolt Pumps, available for all standard mountings, and made to operate in either direction. Five basic sizes — ½ GPM to 130 GPM and for operating pressures up to 1000 p.s.i. to 1500 p.s.i.

Model B.H.F. — TD14W ATECO Inside Mounted Dozer completely equipped with HYDRECO Controls.

Send for complete information including detailed performance data.

HYDRAULIC EQUIPMENT COMPANY

1106 EAST 222ND STREET • CLEVELAND 17, OHIO

craft engine preheating, heating tents, etc. Mr. Clark will be in charge of the military and special contracts department at Louisville.

•

L. M. Evans has been placed in charge of the new Rochester, N. Y., branch office of Worthington Pump and Machinery Corp. This office is located at 1246 Sibley Tower Bldg., Rochester 4, N. Y. Upon receiving his B. S. degree in electrical engineering, Mr. Evans took Worthington's engineering training course at Buffalo. Subsequently he served the company as an assistant test engineer and general line estimator and representative in St. Louis, Buffalo and Syracuse, N. Y.

•

Michael Egan has been appointed sales manager of the chuck division of Supreme Products Inc.

•

Appointment of **Lloyd F. Giegel** as branch manager of the Gary, Ind., sales office of the Reliance Electric & Engineering Co. and the addition of **Daniel J. Donnelly** in a sales engineering capacity to the company's Philadelphia office were announced recently.

•

Formerly executive assistant, **A. W. Winston** has been named assistant manager of the magnesium department of The Dow Chemical Co.

•

Ben King Duffy, sales engineer, has been appointed sales manager for the Pittsburgh district of the Plate & Welding division of General American Transportation Corp. He will serve the western half of Pennyslvania, the eastern half of Kentucky and the states of Ohio, West Virginia and Tennessee.

•

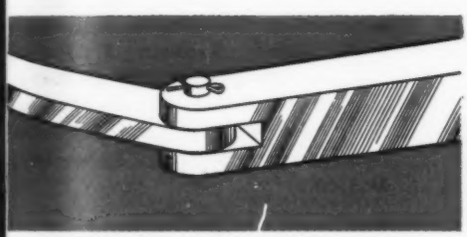
The Duraloy Co., Scottdale, Pa., has appointed **A. M. Miller** as district manager of its Detroit sales office, located at 805 New Center Bldg.

•

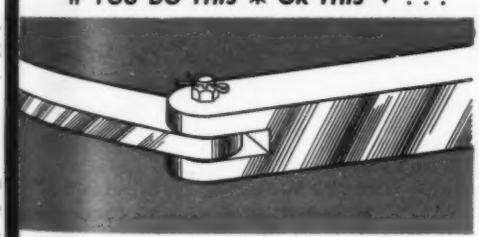
Air Reduction Sales Co., a division of Air Reduction Co. Inc., has announced the appointments of **S. D. Baumer** as vice president of the Airco Equipment Manufacturing division and **Edward H. Roper** as manager of the general technical sales department. Joining the Airco technical sales department in 1941 as steel mill specialist, Mr. Baumer was made assistant manager of that department in 1944 and manager in 1948. Mr. Roper has served in various capacities

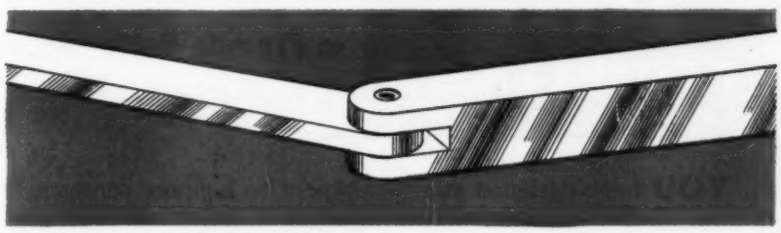
How to replace hinge pins and cotter pins with ROLLPIN self-locking fasteners

Rollpin replaces hinge pin for faster assembly of hinges. Inexpensively and simply driven in place, it cuts assembly costs. Constant spring tension holds Rollpin firm against vibration on heavy-duty automobile door hinges—on lightweight sheet metal hinges for meter or instrument panel covers.



IF YOU DO THIS ▲ OR THIS ▼ . . .





TRY THE ROLLPIN WAY INSTEAD . . . Rollpins offer many advantages as pivot and clevis pins for linkages or yoke assemblies. Heat-treated to provide excellent fatigue resistance and wear characteristics, Rollpins fit flush, grip firmly in the outer or inner members, depending on your design requirements, and are simply, inexpensively pressed in place. They are faster to install than cotter pins or safety wire . . . straight edges protect workers' fingers and clothing. Rollpins are readily removed with a punch . . . can be used again and again . . . assure simplified maintenance.

USE ROLLPINS (1) To replace set screws and rivets. (2) To pin or key gears . . . pulleys . . . levers . . . knobs. (3) As locating dowels, stop pins or shafts for small gear trains.

Once you test their effectiveness you'll want the secure, vibration-proof fastening of Rollpins in your products. Write now for a sample package and full details. Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, N. J.

ROLLPIN TRADEMARK

A PRODUCT OF

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA TRADE MARK

GET YOUR FREE TRIAL ASSORTMENT OF ROLLPINS.

Mail this coupon now.

Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, N. J.

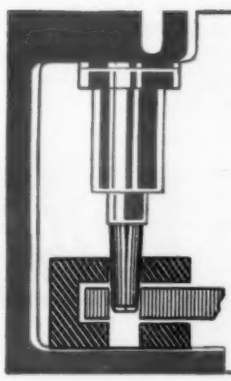
Please send me full application data and test samples of the Rollpin.

Name_____ Title_____

Firm_____

Address_____

City_____ Zone____ State_____



HERE'S HOW ROLLPINS PROVIDE A VIBRATION-PROOF FIT

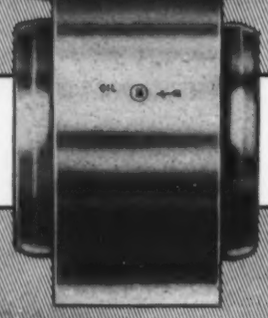
Rollpins are easily pressed into production drilled holes — chamfered ends facilitate automatic or manual insertion.

Rollpins compress as they are driven—are self-retaining in production drilled holes—fit flush. Secondary hole-reaming or riveting operations are eliminated.

Constant spring tension against walls of hole lock Rollpins permanently in place until deliberately removed with a pin punch. Rollpins don't damage the hole and can be used again and again.

Now You Can Improve Your Products *HERE*, Too!

YOUR MODERN EQUIPMENT



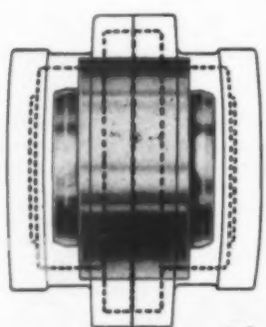
MODERN DRIVING UNIT

New Sier-Bath GEAR COUPLINGS

- Cut Weight 50%
- Cut Size 40%
- Slash Assembly Time
- Slash Down-Time
- Provide Better Protection
- Last Longer

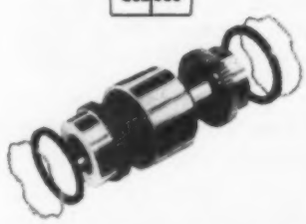
YOU have designed your equipment to be more compact, lighter, less costly to assemble and maintain, more dependable and more durable. And you've seen these advancements in the driving units you specify.

NOW—at long last—you can get these same improvements in the link between machine and driver. Sier-Bath Gear Couplings—the *only* really new gear couplings in years—*provide them all.*



RESULT—your assembly costs go way down—your equipment gets better protection—your customers get better products!

COMPARE: Sier-Bath Gear Coupling shown with two major conventional types of same shaft size, same HP capacity. Smaller, lighter—the new couplings allow more compact designs, put less strain on shafts, bearings.



ASSEMBLED, UNCOUPLED *in seconds!*
Only 7 parts. One-piece smooth sleeve transmits the load—no bolts to shear. Neoprene seals weather-proof the interior. Snap rings removed with a screw driver—yet take 50,000 lbs. of end thrust. No bolts, grids or discs to wear out. Alignment checked in a jiffy.

WRITE FOR BULLETIN
—and name of your nearest Sier-Bath Representative!

Bulletin gives installation photos, cost-cutting advantages, plan drawings, specs for standard, vertical, mill motor and floating shaft types—sizes from ⅞ to 6, HP 4 to 550. (Special sizes and types on request.)

Founded 1905 Member A.G.M.A.

Sier-Bath GEAR and PUMP CO., Inc.

9263 HUDSON BLVD., NORTH BERGEN, N. J.

Also Manufacturers of Precision Gears and Screw and Gearex Rotary Pumps

in the general technical sales department since 1936, was appointed assistant to the manager in 1944 and assistant manager four years later.

•

Jack C. Hurst has been named divisional sales manager of the Pacific Coast division, Revere Copper and Brass Inc., and **Theodore F. Richardson** was appointed district manager of the company's San Francisco office. Mr. Hurst, who has been in the metal business since 1935 and with Revere since 1944, was initially a salesman in the San Francisco office, later becoming district manager there. He will now be located in Los Angeles, where Mr. Richardson was a member of the sales staff before his appointment.

•

Chain Belt Co. of Milwaukee has announced the appointment of five new district sales engineers. They are **Edward D. Williams,** who has been assigned to the Philadelphia district sales office; **Truman J. Hammel,** Kansas City office; **R. W. DeMott Jr.,** New York district sales office; **Kenneth Burch,** working out of the Cleveland office; and **George Robichaud,** in Boston.

•

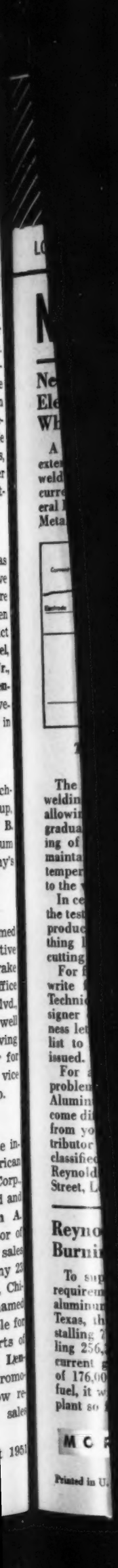
Formerly wih the magnesium technical service and development group, The Dow Chemical Co., **Robert B. Mounsey** has been named magnesium sales representative in the company's Cleveland office.

•

Merten C. Peterson has been named Chicago district manager, automotive division of the Warner Electric Brake & Clutch Co., Beloit, Wis. His office is located at 80 East Jackson Blvd., Chicago, Ill. Mr. Peterson is well known in the automotive field, having served as regional sales manager for Willys-Overland Motors Inc. and vice president of the Flex-O-Tube Co.

•

In a move designed to meet the increased use of its products, American Wheelabrator & Equipment Corp., Mishawaka, Ind., has reorganized and expanded its sales staff. **John A. Silver** has been appointed director of sales and executive head of the sales division, bringing to the company 25 years of experience. **E. B. Rich,** Chicago representative, has been named general sales manager, responsible for all field and direct selling efforts of the company's products. **A. E. Leonhard,** advertising and sales promotion manager since 1936, is now responsible for special work in sales



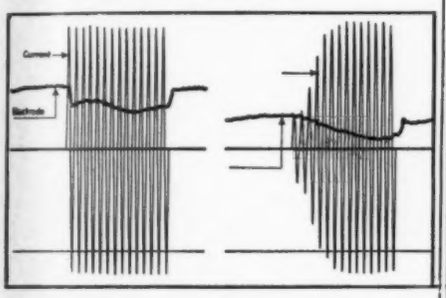
Reynolds
ALUMINUM REPORTER
A SERVICE TO INDUSTRY ON ALUMINUM USES AND DEVELOPMENTS

LOUISVILLE 1, KY. NUMBER 6

NEW MECHANICAL FASTENING METHODS BOOKLET

New Control System Extends Electrode Life 20-30 Times When Spot Welding Aluminum

A new system called "slope control", that extends electrode life 20-30 times when spot welding aluminum with ordinary alternating current welders, has been developed by General Electric and is recommended by Reynolds Metals Company technical staff.



Tip-pressure tracing without (left) and with (right) "slope control"

The new control system restricts the flow of welding current during the first few cycles, allowing the welding current to build up gradually to maximum. This reduces softening of metal under the electrode tip, helps maintain tip pressures, and holds down tip temperatures, thus reducing "sticking" almost to the vanishing point.

In certain oscillograph curves traced during the testing of this system, total amount of heat produced at electrode tips was seen to be something less than one-sixth the usual amount, cutting tip temperature rise tremendously.

For further information on this new system, write for your free copy of the Reynolds Technical Advisor No. 15. Any engineer, designer or executive who requests it on business letterhead will be placed on the mailing list to receive copies of the "Advisor" as issued.

For assistance on any *special* production problem, call on the trained staff of Reynolds Aluminum Specialists ready to help you overcome difficulties and obtain maximum benefits from your aluminum. Call the Reynolds distributor listed under "Aluminum" in your classified telephone directory, or write to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky

Reynolds Building Largest Gas-Burning Electric Power Plant

To supply the tremendous electric power requirements in its new 80 million dollar aluminum reduction plant at Corpus Christi, Texas, the Reynolds Metals Company is installing 78 internal combustion engines totalling 256,300 horsepower and driving direct-current generators with a total rated output of 176,000 kilowatts. Using natural gas for fuel, it will be the largest gas-burning engine plant so far built anywhere in the world.

Latest Data on Various Types of Mechanical Joints and Fasteners Now Available Upon Request

The Technical Editorial Service of the Reynolds Metals Company has produced a new technical book, "Mechanical Fastening Methods for Aluminum."

As stated in the foreword, "In addition to welding, brazing and soldering, a wide variety of mechanical fastening methods are used to join assemblies involving aluminum parts. This book represents an endeavor to supply the designer and manufacturer with data on the various types of mechanical joints and mechanical fasteners for use with aluminum."

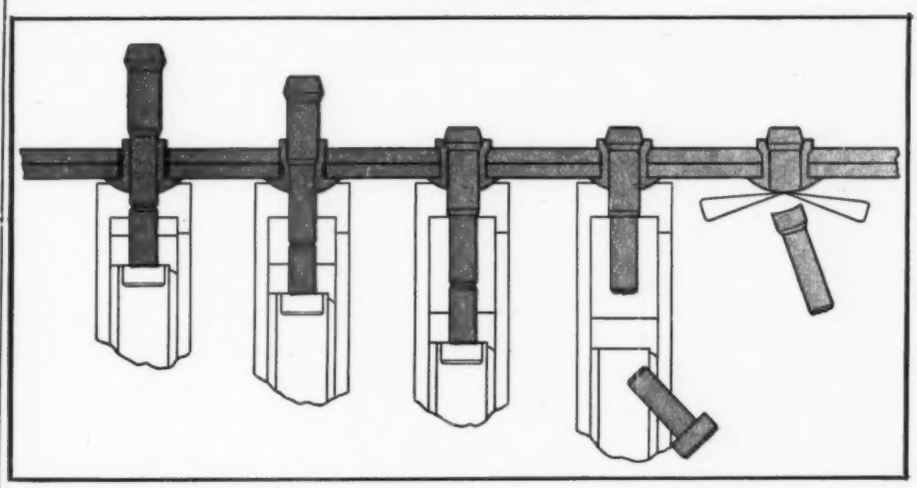


Diagram showing cross-section of method for fastening with self-plugging blind rivets. This is typical of the many explanatory illustrations found in Reynolds newest technical book, "Mechanical Fastening Methods for Aluminum."

Containing all you need to know about fastening aluminum components, this 136-page illustrated booklet is a *must* for your desk reference library. Its handy pocket size makes it ideal for easy carrying and ready accessibility in the shop.

There are tables of related data for the various types of standard rivets, including dimensions and number of pieces per pound, lengths of rivets for cone-point and button-type driven heads, recommended hole sizes with shear and bearing areas for both hot and cold-driven rivets, and maximum loads for single rivet in shear

You will find in this book answers for your questions on standard and special rivets, standard and special screw fasteners, nails and pins, metal stitching, mechanically formed joints, resin bonding and others.

Illustrated above is an example of one of the complete diagrams explaining the method of riveting, using self-plugging blind rivets.

Application of the latest 1951 fastening methods like these means increased production capacity and lower costs for every type of aluminum assembly

The Reynolds Metals Company states in the book that they will be glad to grant permission to any technical writers to use transcripts from the book. Also, technical writers and editors may obtain glossy 8 x 10-inch photoprints of any of the book's illustrations.

For manufacturers or designers having a special development problem not covered by this book, Reynolds offers the services of its trained staff of aluminum specialists. Let them show you how to overcome difficulties and set up for fast, economical production. For prompt service, call the Reynolds field office listed under "Aluminum" in your classified telephone directory.

(A reprint of the book's riveting section, the most important mechanical joining method, is available in quantities for distribution to students in schools, colleges and technical groups without charge.)

For your *free* copy of the valuable handbook described above, plus a complete index of Reynolds technical literature, write on business letterhead (otherwise price is $1.00) to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

Printed in U. S. A.

Aluminum Pipe Makes Portable Sprinkler Irrigation Reality

Use of portable sprinkler irrigation systems on American farms has grown spectacularly since 1945. One of the largest factors causing this increase has been the tremendous advantage of aluminum irrigation pipe.

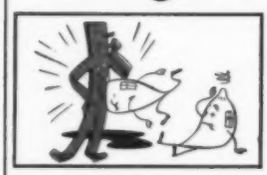
Extreme portability due to light weight, great strength offering high pressure resistance, plus rust and corrosion resistance . . . all these contributed to the demand for aluminum irrigation pipe and made *portable* sprinkler irrigation a reality.

During the present emergency, aluminum pipe of this type is being used as the basic component of the "Superbazooka", the 3.5 inch rocket-launcher. If you can find a use for extruded aluminum tubing in the design of your future products, call the Reynolds Aluminum Specialist . . . let him work with you to assure the maximum benefits of aluminum. His development and research skill is backed by the experienced staff of the Reynolds Technical Service. For further information call the Reynolds distributor listed under "Aluminum" in your classified telephone directory. Or, write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

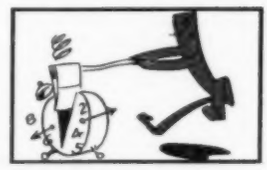
New Idea for Artists' Medium

Swiss experiments indicate that 1/8-inch aluminum, coated with a porous oxide skin, provides a practical and permanent working foundation for oil painting. It doesn't tear, split or wrinkle like canvas and takes less storage space. The smooth surface paints easier, gives more brilliant colors.

Shippers of Defense Material Find Nothing Protects Like Aluminum Foil



Keeps Moisture Out—Reynolds Plain Aluminum Foil is a positive barrier against transmission of moisture vapor. In gauges .0015" and heavier, it has a zero moisture-vapor-transmission rate.

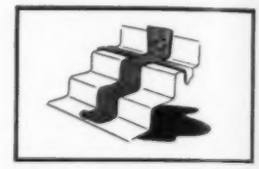


Cuts Packaging Time—Reynolds Plain Aluminum Foil offers maximum conformity to the object to be packaged. Shapes easily by hand. No valuable time lost tying, binding or taping.

Naturally Greaseproof—Reynolds Plain Aluminum Foil prevents greases on parts from drying out or hardening, thereby losing their value. Aluminum is naturally greaseproof on both sides.

Maintains Top Efficiency Indefinitely—Reynolds Plain Aluminum Foil does not depend on treatments for waterproof qualities, therefore it is not affected by long exposure to dry air or heat.

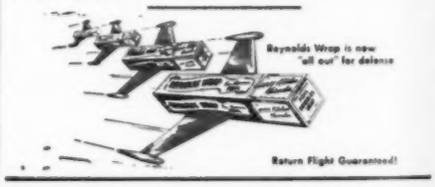
Absolutely Non-Absorptive—Reynolds Aluminum Foil does not absorb dipping compounds as other barrier materials do. This means a direct cash saving on the dipping material used.



No "Spring Back"—Reynolds Plain Aluminum Foil is "dead soft" and holds molded contours. Excellent for parts impractical to package by old-fashioned methods and materials.

Reynolds Pure Aluminum Foil is particularly suited as an intimate wrap for parts which have large air voids and cannot be dipped without undue bubbling. The ease with which it conforms to and holds shape leaves less "dead air space" in package.

For your copy of the FREE booklet "How, Why and When You Should Consider Protective Packaging with Aluminum Foil" write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.



Aluminum Medical Chest Another Example of Reynolds Parts Fabrication Service

Complete Facilities Help Manufacturers with Military Orders

Another example of the complete and valuable service to industry performed by the Reynolds Parts Fabrication Service, these aluminum medical chests are now being produced for the Armed Forces Medical Units. The wide range of facilities available to manufacturers through the use of this service is demonstrated by the blanking, drawing, spot-welding, seam-welding, finishing and other allied operations necessary to produce this type of chest.

Formed of Reynolds .091" Aluminum, these chests have reinforced corners and welded gasket retaining channels for strength and rigidity. Flush mounted hardware allows containers to be stacked on any side. Stacked flat, the nesting feature of the design prevents sliding even when stack is tilted. Gum rubber gaskets assure water-proofing.

Shipping containers like these are only one of the many applications of the skill and production facilities of the Reynolds Parts Fabrication Service. This service provides all manufacturers with extra assembly lines when needed. Through the use of this program, the manufacturer is assured of a steady flow of inspected parts whenever needed and in whatever quantities desired. Quotations on aluminum parts can be furnished to the manufacturers' designs and specifications.

Probably one of the most important features of the Parts Fabrication Service is the tremendous savings in vitally needed scrap . . . averaging 30% and often as high as 75%! This results in savings on shipping, storing and handling charges plus making important scrap readily available for remelting at the mill. On "DO" orders where the allocation is in pounds of metal, the manufacturer gets full value from his allocation, receiving the exact number of parts available from the pounds of metal allocated.

For further information on the Parts Fabricating Service and how it can help your production, merely call the Reynolds office listed under "Aluminum" in your classified telephone directory. Or, write to Reynolds Metals Company, 2065 South Ninth Street, Louisville 1, Kentucky.

New Book Tells Complete Reynolds Aluminum Story

A new booklet has been prepared for distribution to all those interested in modern metal developments. This 45-page booklet, "Reynolds Aluminum and the company that makes it", is the first complete compilation of the facts about the company that did more than any other to bring America's aluminum production up to the point it has reached today. The booklet presents the principal operations of Reynolds Metals Company under "normal conditions" and during the present rearmament program.

Profusely illustrated and handsomely bound, the booklet is available upon request to those writing on business letterhead. Address the Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

development and **S. S. Deputy,** sales manager, has been given special executive and sales assignments. He will also co-ordinate sales and production and handle customer services. The company also recently appointed **George A. Lieser** as special sales engineer and **Earl E. Broadhag** as development engineer for its new Liquamatte equipment.

♦

Robert E. Huthsteiner has been elected president of Cummins Engine Co. Inc. Associated with the company almost ten years, he joined Cummins as sales manager in March of 1942.

♦

The Bridgeport Brass Co. has announced the appointment of **L. E. Menns** as Pacific Coast sales manager. Mr. Menns, who has been serving as Los Angeles district manager, will be in charge of the San Francisco district office and warehouse and will be responsible for the sale of all Bridgeport products on the Pacific Coast. Sales activities of the company's Los Angeles and San Francisco offices and warehouses have been consolidated to give improved service to customers in that area.

♦

Having served as sales engineer out of the company's New York City mill-branch warehouse since 1946, **Martin J. Holleran** has been named assistant manager of tool steel sales by The Carpenter Steel Co., Reading, Pa.

♦

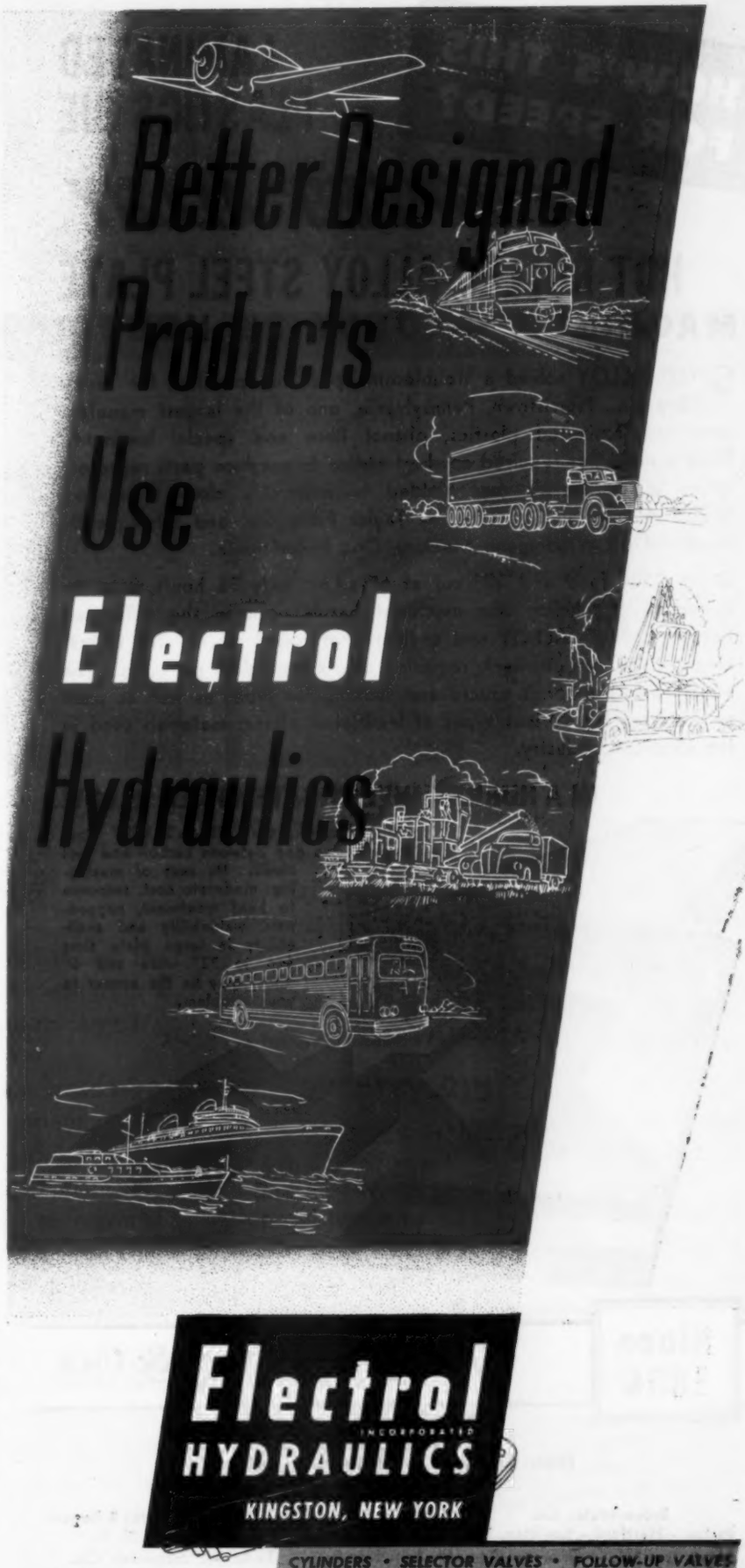
Wolverine Tube division of Calumet and Hecla Consolidated Copper Co. Inc. has announced the appointment of **W. H. Maxwell** as assistant to the vice president for the firm in Washington. Formerly director of sales for the Wolverine Tube division, Mr. Maxwell will work closely with government control agencies and on brass mill industry contacts.

♦

With headquarters in Youngstown, **James F. Dollison** has joined the Republic Rubber division, Lee Rubber & Tire Corp., as field engineer, serving northeastern Ohio and western New York.

♦

Rodger J. Mueller has been appointed manager of the Youngstown office of The Falk Corp., Milwaukee. He will serve customers in sections of Ohio, Pennsylvania and West Virginia. **F. J. Bowers,** who has represented Falk for many years in the Youngstown area, will remain in the office in an advisory and consulting



HOW'S THIS FOR SPEED?

LAMINATED PLASTICS DIE

of SPEED ALLOY

HOT ROLLED ALLOY STEEL PLATE

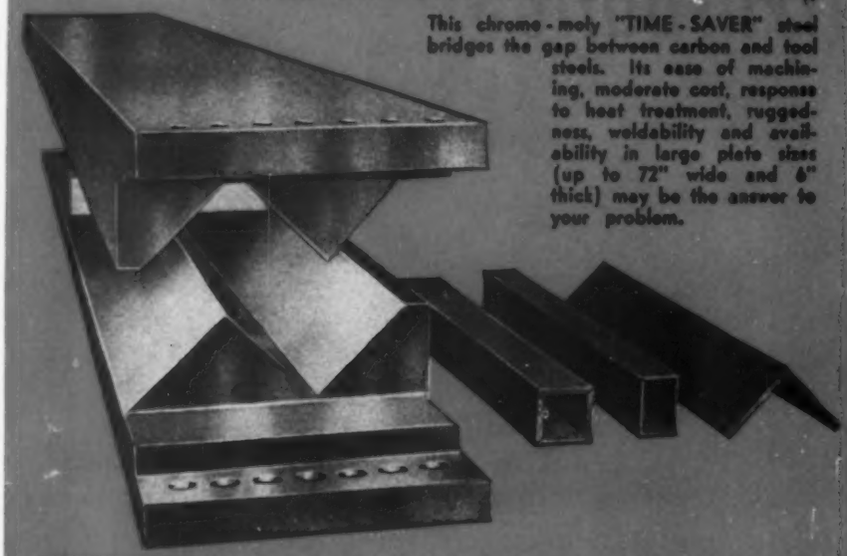
MACHINED IN ONLY 35 HOURS!

SPEED ALLOY solved a troublesome pilot run problem for Taylor Fibre Co., Norristown, Pennsylvania, one of the largest manufacturers of laminated plastics, phenol fibre and special laminates. Since a mold was required on short notice to produce parts representative of production runs molded to extremely close tolerances, SPEED ALLOY was selected by Taylor Fibre Co. and subsequently machined by Wiedemann Machine Co., Philadelphia.

Using .030" feed and 3/8" cut at 65 s.f.m., only 35 hours were required for machining, the machinist barely noticing the difference between SPEED ALLOY and ordinary hot rolled plate. The as-machined finish was excellent, requiring only emery cloth polishing. The mold illustrated forms square and rectangular tubes as well as plain angles from the various types of laminated plastic materials used in the electronic industry.

IN A HURRY? INVESTIGATE SPEED ALLOY!

This chrome-moly "TIME-SAVER" steel bridges the gap between carbon and tool steels. Its ease of machining, moderate cost, response to heat treatment, ruggedness, weldability and availability in large plate sizes (up to 72" wide and 6" thick) may be the answer to your problem.



Since 1856

W. J. HOLLIDAY & CO. (INC.)

SPEED STEEL PLATE DIV.
120 139th St., Hammond, Ind.
Plants: Hammond and Indianapolis, Indiana

DISTRIBUTED BY

Brown-Wales Co. Boston - Hartford - Lewiston, Me.
Bridgeport Steel Co. Bridgeport, Conn.
Bacia, McCarthy & Rogers Buffalo, N. Y.
Burger Iron Co. Akron, Ohio
Grommer, Dempsey & Hudson, Inc. Newark, N. J.
Earle M. Jorgensen Co. Los Angeles-Houston-Oakland
Passaic County Steel Service, Inc. Paterson, N. J.
Peckover's Ltd. Halifax - Montreal - Toronto - Winnipeg - Vancouver
Peninsular Steel Co. Detroit, Mich.
Pidgeon-Thomas Iron Co. Memphis, Tenn.
Horace T. Potts Co. Philadelphia - Baltimore

capacity. Two other district office appointments were also announced. **D. B. Bodholdt** succeeds Mr. Mueller in the Pittsburgh office under the direction of **D. Adams**, and **D. R. O'Hare** will assist **D. S. Ferree** in the Philadelphia office.

♦

James P. Stewart, previously executive vice president, has been elected president of De Laval Steam Turbine Co., Trenton, N. J., and **Wencel A. Neumann Jr.** has been elected vice president of industrial sales, with responsibility for the industrial and commercial sales of steam turbines, pumps, blowers and compressors, IMO rotary pumps and power transmission equipment.

♦

Detroit Broach Co. has announced the appointment of **J. E. Polhemus** as representative for southern and eastern Wisconsin. His headquarters will be at 833 East Kilbourn Ave., Milwaukee 2, Wis.

♦

To handle the company's contacts with distributors of mechanical rubber goods products, **Richard W. Sabine** has been named manager of distributor sales in the mechanical goods division of Goodyear Tire & Rubber Co. He was previously senior staffman in charge of mechanical goods advertising and sales promotion.

♦

Lawrence L. Garber, general manager of American-Fort Pitt Spring division, H. K. Porter Co. Inc., Pittsburgh, has been elected a vice president of the company.

♦

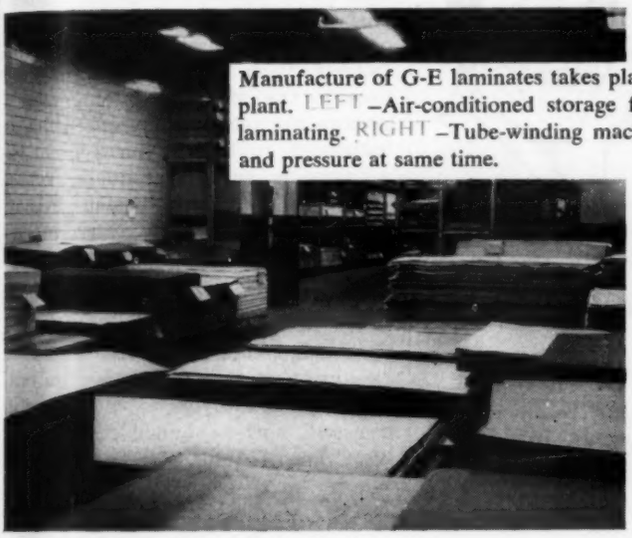
Assistant general manager of sales at Sharon Steel Corp., Sharon, Pa., **W. J. McCune** has been appointed chief of the stainless steel section of the National Production Authority. Mr. McCune's appointment is for a period of six months, after which he will return to Sharon, where he directs stainless and alloy steel sales.

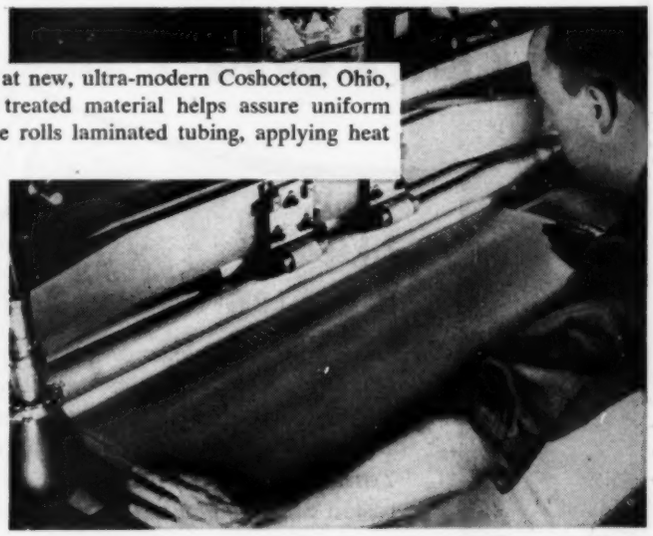
♦

W. C. Spruce, direct factory representative of the spray painting and finishing equipment division of the DeVilbiss Co., has been promoted to Southwest district manager. He will continue to maintain offices at the company's branch, 1515 Dragon St., Dallas, Tex., and will supervise sales activities in the newly created Southwest district, which includes Texas, Louisiana, Mississippi, Arkansas, Oklahoma, New Mexico, a section of western Tennessee and northwestern Alabama.

LAMINATES NEWS

News of General Electric Laminated Plastics that can be of importance to *your* business.





Manufacture of G-E laminates takes place at new, ultra-modern Coshocton, Ohio, plant. LEFT—Air-conditioned storage for treated material helps assure uniform laminating. RIGHT—Tube-winding machine rolls laminated tubing, applying heat and pressure at same time.

EXCEPTIONAL CHEMICAL RESISTANCE IS FEATURE OF NEW G-E LAMINATE

Wherever corrosive chemicals are handled, it's worth considering equipment fabricated from a new phenolic (plastics) laminate recently announced by General Electric.

Designated G-E 2016, the new material is available in sheets and tubes. Important advantages for a wide range of industrial applications are *exceptional chemical resistance, mechanical toughness, resistance to repeated impacts.*

G-E 2016 is produced with canvas base material. Investigate its cost-saving possibilities in pipe lines, for fabricating plating tanks, dye vats, for structural work—where extra strength and chemical resistance are most important. *Write Section Y-4, Chemical Division, General Electric Company, Pittsfield, Massachusetts.*

G-E Laminates for Refrigerators

Laminated plastics for refrigerator inner-doors are preformed by G.E. and supplied to many major manufacturers. Advantages of this use of G-E laminates over metal materials mean better insulation, less condensation, improved finish, rustlessness, reduced weight, elimination of denting. *Look into G-E molded laminates for your products!*

Complete Line of G-E Laminates

General Electric produces a complete line of laminated plastics—either molded or in forms of sheets, tubes and rods, with cloth, paper, glass fabric or special bases—for a wide variety of applications. ***(Also, look to General Electric for silicone insulation, insulating varnishes, sealing and filling compounds, mica insulation, varnished cloth and tape.)***

DEFENSE CONTRACTORS!

Investigate the many ways G-E Laminated Plastics do the work of metals—and do it better—as parts, structural materials, electrical insulation. General Electric is ready to work with you in every stage of product development.

You can put your confidence in

GENERAL ELECTRIC

NOW—
the advantages of
TEFLON*
plus
RAPID, LOW-COST PRODUCTION OF PARTS
Close tolerance extruded *Teflon* rods in a wide range of sizes recently developed by our engineers, offer fabricating advantages over the short molded lengths previously available. Where *Teflon's* electrical properties or exceptional corrosion or heat resistance is needed, uniform parts can be readily machined from our rod.
Typical *Electrical* Properties of *Teflon:* Electrical properties of *Teflon* are practically unchanged through its useful service range of –100°F. to 480°F. Short-time dielectric strength as high as 1,000 to 2,000 volts per mil, in 2 to 10 mil thicknesses. Long-time dielectric strength reported over 1,000 volts per mil in the absence of corona. Electrical loss factor over frequencies from 60 cps to 30,000 mc is less than 0.0005.
*Teflon is a trademark of the E. I. Dupont Co.
New Folder Contains Complete Information on available sizes of Teflon and Nylon rod, strip and tubing. Write for your copy.
THE POLYMER CORPORATION
Reading, Pa.
NYLON & TEFLON
ROD
STRIP
TUBING
Pioneer Producers of Nylon Rod and Strip

SALES Notes

TO BETTER serve the Detroit industrial area, **Quaker Rubber Corp.**, division of **H. K. Porter Co. Inc.**, Philadelphia, has opened a stock-carrying branch warehouse and sales office at 872 West Milwaukee Ave., Detroit, Mich. The new branch will provide the state of Michigan with prompt service on a complete line of industrial rubber products including automotive rubber products, rubber conveyor and transmission belting, V-belts, hose, packing and molded rubber products.

♦

The **Cambridge Wire Cloth Co.**, Cambridge, Md., has announced an expansion of the facilities of its metal specialties division. Sales activities will now be under the direction of Wallace I. Pink.

♦

A new department has been established by **The Essex Wire Corp.** of Fort Wayne, Ind., which will engage in the design, development, manufacture and marketing of luminous tube (neon), oil burner ignition and fluorescent lighting transformers.

♦

The Hilliard Corp. has appointed **Guy T. Martin & Co.**, 642 East Olive St., Gardena, Calif., as representative in that state to distribute its line of lubricating, fuel and industrial oil purification equipment.

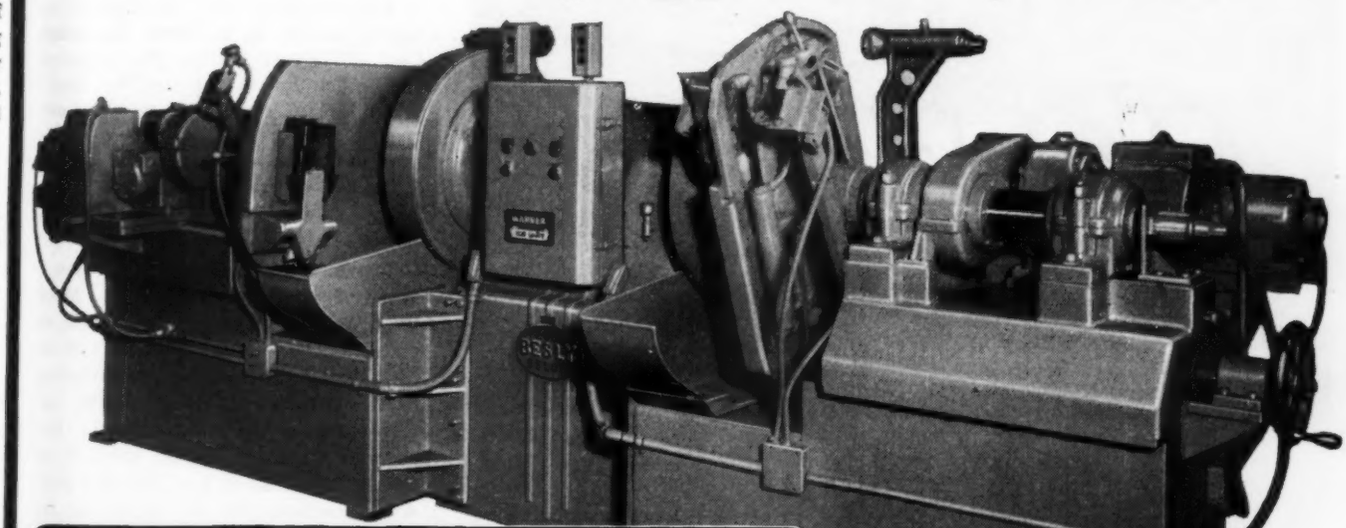
♦

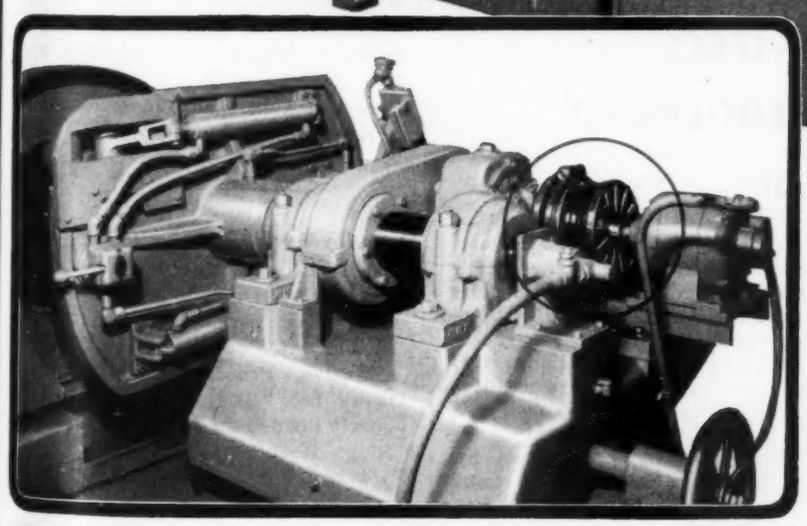
In order to provide better service, **Consolidated Engineering Corp.** has moved to 300 North Sierra Madre Villa, Pasadena 8, Calif.

♦

Several new distributors were recently named by **Allis-Chalmers Mfg. Co.**, Milwaukee. **The Nebes Supply Co. Inc.**, 231 Mt. Vernon St., Lowell, Mass., has been appointed as a distributor for Texrope drive equipment in Middlesex county in Massachusetts. Two other new Texrope distributors are **Tools and Supplies Inc.**, 3131 Olive St., St. Louis, Mo., serving sections of Missouri, Illinois and Indiana, and **Independent Distributing Co.**, 923 South Eighth St., St. Joseph, Mo., serving eight counties in Missouri and three in Kansas. Also, **Industrial Supplies Co.**, 324 North Seventh St., Steubenville, O., has been named a distributor for motors

FREE HAND GRINDING ELIMINATED on heavy journal bearings with WARNER ICB equipped Besly Grinder



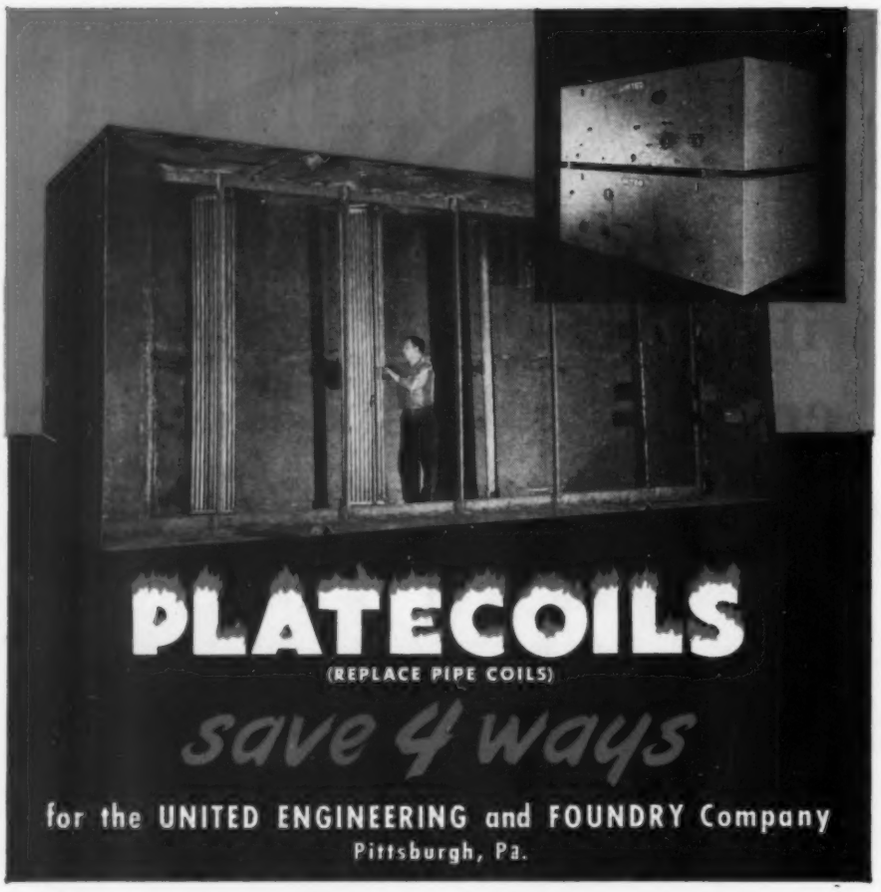


Full view of Besly special two-station grinder for facing off bronze journal bearings. Machine incorporates two Warner ICB combination electric clutch and brake units. (See close-up). Machine completes three bearings per minute, eliminates human error of hand grinding, assures uniformity. ICB units start, stop and position work pieces at each work-holding station.

WARNER ICB units offer a wide variety of design possibilities in the control and operation of nearly all types of machinery. Simple in construction, they occupy little space. Operated electrically, they provide instant, smooth response. Already being used on many different kinds of machinery to simplify control, eliminate complicated mechanical drives, increase production, provide greater safety and reduce maintenance, WARNER ICB units are available in several sizes, as single clutch or brake units, or in combination. Write today for complete information. Our engineers will consult with you, at no obligation. WARNER ELECTRIC BRAKE & CLUTCH CO., Beloit, Wisconsin. Dept. MD.

WARNER
ICB UNIT

WARNER ICB Units are manufactured by Warner Electric Brake Mfg. Co. — pioneers in the field of electric brake design and application since 1927.



1 EASIER TO INSTALL
2 TAKE LESS TANK SPACE
3 REQUIRE LESS MAINTENANCE
4 COST LESS TO USE

When United Engineering and Foundry Company first decided to use Platecoils in their Lubricating tanks, ease of installation was the determining factor. Weighing only half as much as equivalent pipe coil, Platecoils are much easier to handle and take less time to install. However, other benefits have resulted that are equally important. Platecoils take only about half as much space in the tank to give it greater capacity. The absence of tube failure and less trouble with leakage reduce maintenance to an absolute minimum. The net result is that Platecoils cost less to install and less to use.

You can cut your tank heating and cooling costs to rock bottom by using Platecoils. You will save up to 50% in initial costs. Your tanks will heat or cool faster thus saving many non-productive hours. And you will save many hours in maintenance time. Send for full details today. Ask for bulletin No. P71.

PLATECOIL gives you these ADVANTAGES
Cleaned and Repaired Without Dumping Tank Solution
Greater BTU Transfer Per Unit Area
Weighs Only Half as Much as Pipe Coil
No Threaded Joints in Tank
Increased Tank Capacity
Fast, Easy Installation
Easy-to-Clean

PLATECOIL
Division
KOLD-HOLD MFG. CO.
LANSING 4, MICHIGAN

and controls in eight eastern Ohio and four northern West Virginia counties, and **Joe Summers & Co. Inc.**, Mission, Tex., has been appointed a distributor for the company's pumps in Willacy, Cameron, Hidalgo and Starr counties in Texas.

♦

To handle its complete line of transformers, **The Standard Transformer Co.**, Warren, O., has appointed the **Carl A. Froebel Co.** as representative for eastern Missouri and southern Illinois.

♦

Ampco Metal Inc., Milwaukee, has appointed the **R. J. Greer Equipment Co.**, 116 South Salina St., Syracuse, N. Y., as distributor for the Ampco Weld line of resistance welding electrodes. Territory of the new distributor includes the state of New York except metropolitan New York.

♦

The industrial chrome division of **Ward Leonard Electric Co.**, Mount Vernon, N. Y., has announced the appointment of three distributors for its new Chromaster line of industrial hard chrome plating units and Chromasol, the noncritical hard chrome plating solution used in the units. **S. B. Roby Co.**, 208-214 South Ave., Rochester 4, N. Y., is the representative in the Rochester area; **Syracuse Supply Co.**, 314 West Fayette St., Syracuse 1, N. Y., in the Syracuse area; and **Logan Hardware & Supply Co.**, Huntington, W. Va., in West Virginia.

♦

Warren Steam Pump Co. Inc., Warren, Mass., manufacturer of pumping machinery, is now represented in upstate New York through a recently opened office of its Pittsburgh representative, **Process Industries Engineers Inc.** The latter company recently opened an office at 703 Temple Bldg., Rochester 4, N. Y.

♦

A new district agency with complete sales and service facilities for **The Wheelco Instruments Co.** line of recorders, controllers and combustion safeguards has been opened for the state of West Virginia. The new agency, **Engineering Products Co.** is located at Charleston 24, W. Va.

♦

Peaslee-Wells Inc., 1285 Riverdale St., West Springfield, Mass., has been appointed as an authorized distributor for western Massachusetts, eastern Vermont and western New Hampshire by **Carboloy Co. Inc.**, Detroit.

RACINE HYDRAULIC PUMPS

Simplify your Circuit

Less valves and controls in a circuit provide easier installation and lower initial costs.

RACINE "Variable Volume" Pumps eliminate relief valves and extra piping. They reduce horsepower requirements and avoid excessive heat losses. Over-all cost of motor and reservoir is usually reduced. Efficiency is high because RACINE Pumps "put all of the oil to work."

A wide range of governor controls provide pumping action at the proper pressure and volume to handle any given job most effectively. These interchangeable governors are an exclusive RACINE feature.

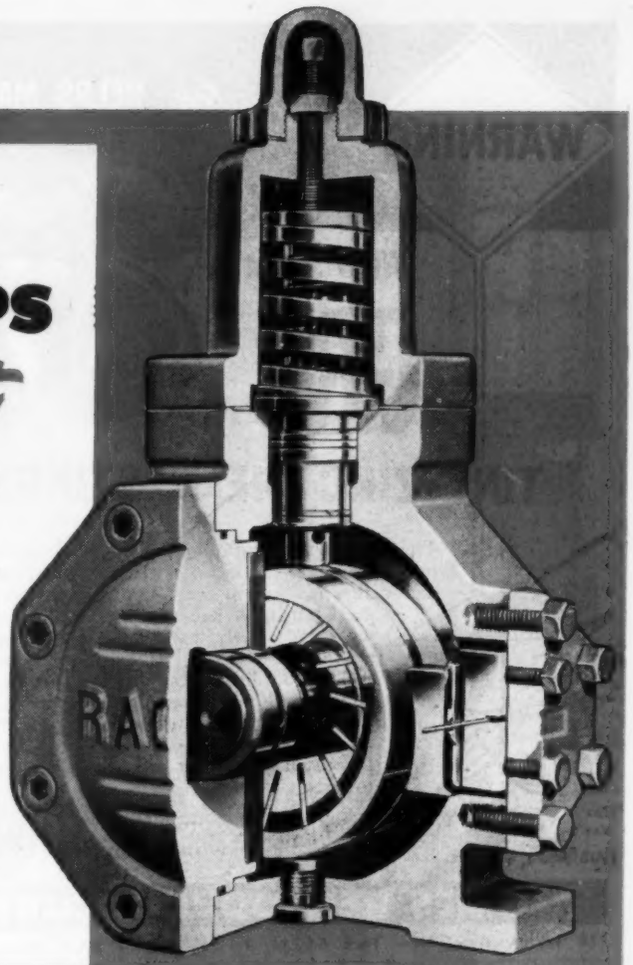
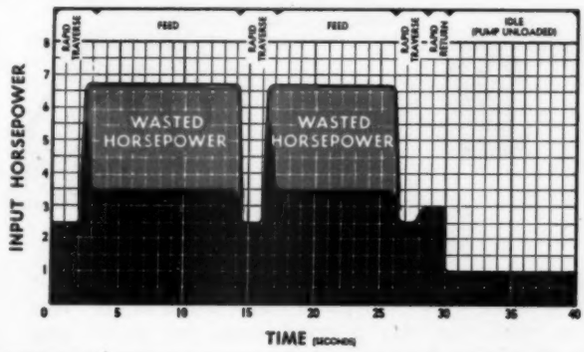


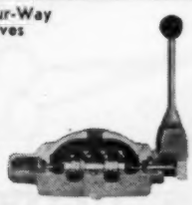
Chart below illustrates power consumption on a typical machine tool. Black area is power used with a No. 2 RACINE "Variable Volume" pump controlled by a pressure compensated feed valve. Area in color is power wasted by a constant volume pump, bypassing most of its volume through a relief valve during the feeding cycle.



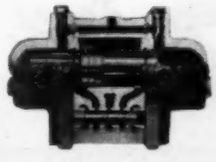
Write for new 3-color Catalog P-10-D covering RACINE's complete line of "Variable Volume" Pumps, Valves and Pressure Boosters.

OTHER RACINE HYDRAULIC PRODUCTS

Four-Way Valves



Pressure Boosters



Pump & Reservoir Units

RACINE TOOL AND MACHINE CO.

1773 State Street, RACINE, WISCONSIN, U. S. A.

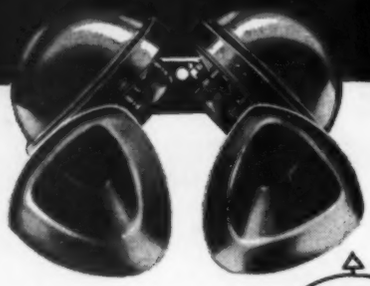
WARNING

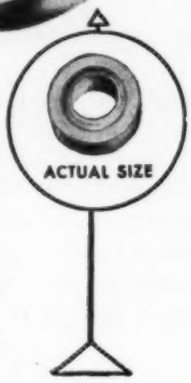
Sparton HELPS MAKE IT SURE

WITH . . .

GRC

TINY ZINC DIE CASTINGS





The Sparks-Withington Company found small inexpensive GRC zinc die castings made ideal supporting bracket spacers for their Sparton air-shell horns. Whatever you manufacture—warning signals, bazookas or electronics equipment—it will pay you to consider the speed and economy of die casting for your small metal parts. Gries' exclusive facilities turn out simple or intricate parts in one automatic operation—completely trimmed, ready for use. 100,000 pieces to many millions.

Max'm. Weight ½ oz.
Max'm. Length 1¾ in.
Smallness Unlimited

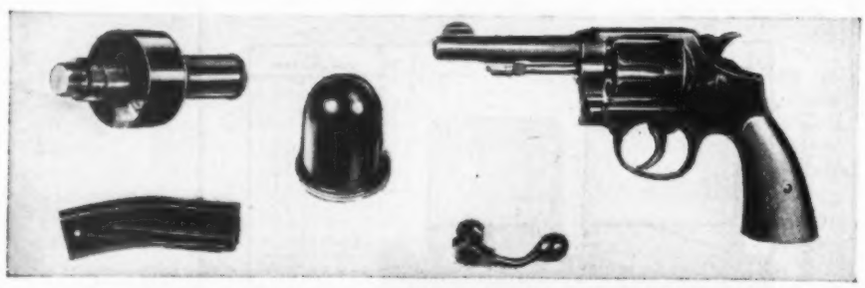
Write today for bulletin and samples.

GRIES REPRODUCER CORP.

118 Willow Ave., New York 54, N. Y. ● MOtt Haven 9-2476

BLACK MAGIC

The PROVEN Finish for Military and Civilian Items



Black Magic is a lustrous, permanent black for steel and iron. It meets military specifications for this type of black oxide finish. Not only an attractive finish but also a good bond for paints and lacquers. Black Magic is being used for many electroplated finishes affected by material shortages and restrictions. For fully automatic or hand operated tanks. Write for our complete catalog.

Items for civilian use with BLACK MAGIC finish.

MITCHELL-BRADFORD CHEMICAL COMPANY
MODERN METAL FINISHES
• 2446M MAIN ST., STRATFORD, CONN. •

BLACK-MAGIC OXIDE BLACKING SALTS
WITCH-DIP & WITCH-OIL FINAL FINISHES

SILCO *Glass-Base* PROTECTIVE COATING
HEAT TREATING SALTS. CLEANERS. ETC.

Meetings

AND EXPOSITIONS

Aug. 30-Sept. 13—

The British Engineers Association. Engineering, Marine and Welding Exhibition to be held in Olympia, London, England. Additional information may be obtaned from J. V. Topham, secretary, 32 Victoria St., London, S.W. 1, England.

Sept. 1-10—

European Machine Tool Exhibitions. First exhibition to be held at the Porte de Versailles, Paris, France. Additional information may be obtained from A. J. Gibbs Smith, 477 Streetsbrook Rd., Solihull (Warwickshire) England.

Sept. 3-7—

Institute of the Aeronautical Sciences — Royal Aeronautical Society. Third International Aeronautical Conference to be held at Brighton, Sussex, England. Additional information may be obtained from Robert R. Dexter, secretary, 2 East 64th St., New York 21, N. Y.

Sept. 10-13—

Society of Automotive Engineers. Tractor and production forum to be held at the Schroeder Hotel, Milwaukee, Wis. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager. (Headquarters for this meeting were incorrectly listed in our June issue as being at the Biltmore Hotel, Los Angeles, Calif.)

Sept. 10-14—

Instrument Society of America. Sixth National Instrument Conference and Exhibit to be held in the Sam Houston Coliseum, Houston, Texas. Additional information may be obtained from society headquarters, 921 Ridge Ave., Pittsburgh 12, Pa.

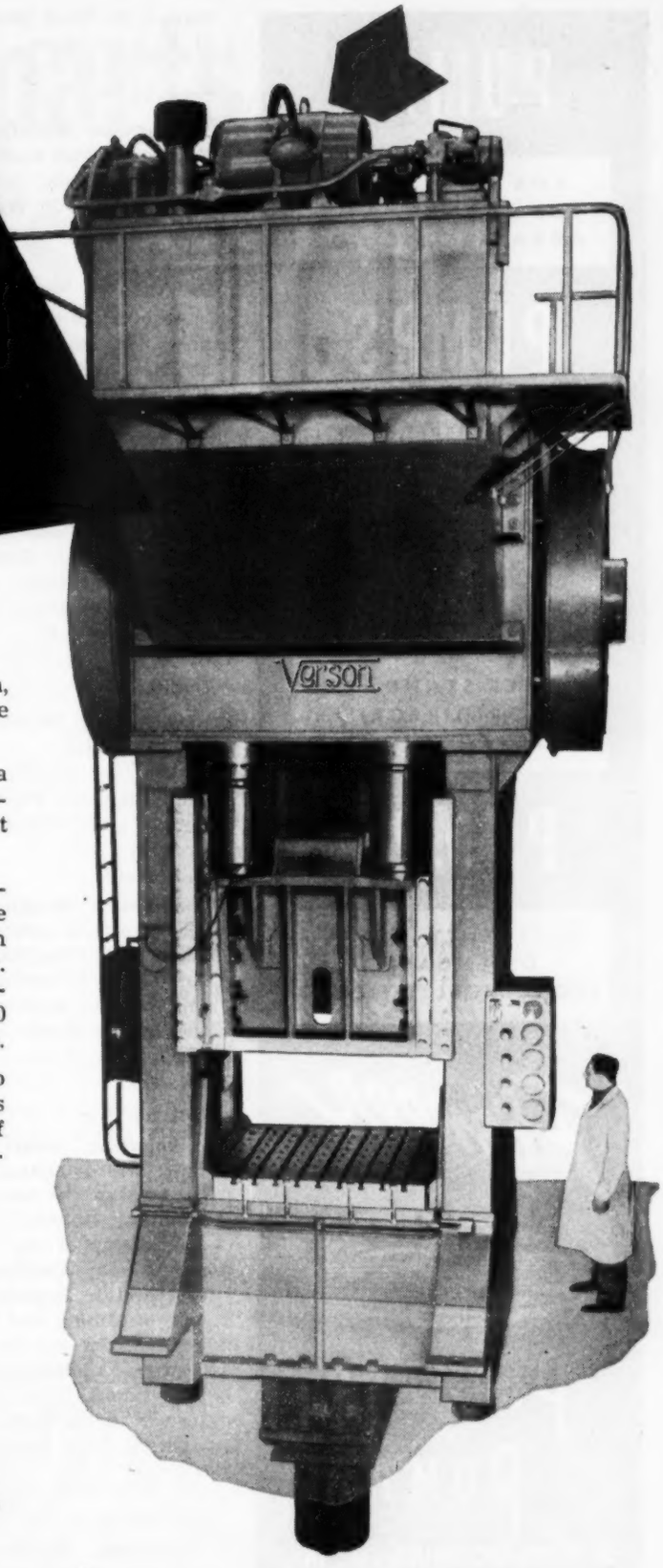
Sept. 10-14—

American Society of Mechanical Engineers. Industrial Instruments and Regulators Division, joint conference with Instrument Society of America to be held at Houston, Texas. C. E. Davies, 29 West 39th St., New York 18, N. Y. is secretary.

Sept. 24-26—

American Society of Mechanical Engineers. Petroleum mechanical engineering conference to be held at Hotel Mayo, Tulsa, Okla. C. E.

Machine with a POWERHOUSE PUNCH!



In one mighty blow, this giant 850-ton, double-action, deep-drawing Verson Allsteel press forms an intricate automobile part.

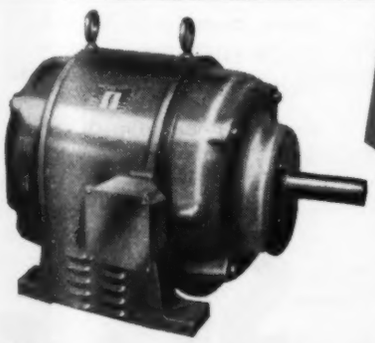
Multiply this by seven strokes a minute, 3 shifts a day, seven days a week and you have a rugged operating schedule . . . one which the Howell motors that power this fine press take right in stride.

Howell engineers worked closely with this manufacturer to select the *right* motor for each job. The main drive motor is a Howell 50 H.P. high slip, high torque motor designed specially for punch press work. The self-adjusting blankholder is driven by a hydraulic pump, powered by a 50 H.P. Howell motor. A 20 H.P. Howell motor operates another hydraulic drive.

Howell will devote the same care and attention to your electric motor problems and needs. With this cooperation and Howell quality, you're assured of motors that will stand up under the heaviest production load over long periods without interruption.

May we help you?

HOWELL ELECTRIC MOTORS COMPANY
Howell, Michigan



Howell Type F Motor. A high slip, high torque motor designed for punching and shearing operations. Sizes ½ to 200 H.P. in open frames; ½ to 125 H.P. in enclosed frames.

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Precision-built industrial motors since 1915

PUMPS

FOR COOLANTS, LUBRICANTS, AND ABRASIVE LIQUIDS

PUMPS

POSITIVE DISPLACEMENT AND IMPELLER TYPES

PUMPS

J. I. C. STANDARDS OR DIRECT MOTOR CONNECTED

PUMPS

FOR TWENTY YEARS—DEPENDABLE, ECONOMICAL, EFFICIENT

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PIONEER PUMP

& MANUFACTURING CO., INC.

STANDARD OR SPECIAL, FOR EVERY MACHINE TOOL AND INDUSTRIAL USE

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DETROIT 3, MICHIGAN

WRITE FOR CATALOG

Davies, 29 West 39th St., New York, N. Y., is secretary.

Sept. 25-28

American Society of Mechanical Engineers. Fall meeting to be held at Hotel Radisson, Minneapolis, Minn. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

Oct. 1-4—

Association of Iron and Steel Engineers. Annual convention to be held at the Sherman Hotel, Chicago, Ill. T. J. Ess, Empire Bldg., Pittsburgh 22, Pa., is managing director.

Oct. 11-12—

ASME Fuels and AIME Coal Division Joint Conference to be held at Hotel Roanoke, Roanoke, Va. Additional information may be obtained from C. E. Davies, 29 West 39th St., New York, N. Y.

Oct. 13-17—

Packaging Machinery Manufacturers Institute. Nineteenth annual meeting to be held at the Mid Pines Club, Southern Pines, N. C. Boyd H. Redner is president.

Oct. 14-19—

American Welding Society. Thirty-second annual meeting to be held at Hotel Book Cadillac, Detroit, Mich. Additional information may be obtained from society headquarters at the Hotel Book Cadillac, Detroit, Mich.

Oct. 15-19—

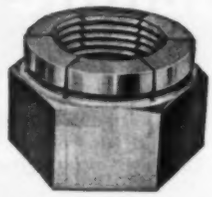
American Society for Metals. Thirty-third annual metal show to be held at the Michigan State Fair Grounds, Detroit, Mich., under the sponsorship of the American Society for Metals; American Welding Society; Metals Branch, American Institute of Mining and Metallurgical Engineers; Society for Non-Destructive Testing. Additional information may be obtained from society headquarters, National Metal Congress & Exposition, 7301 Euclid Ave., Cleveland 3, O.

Oct. 22-24—

National Electronics Conference. Seventh annual conference to be held at the Edgewater Beach Hotel, Chicago, Ill., under the sponsorship of the American Institute of Electrical Engineers, the Institute of Radio Engineers, Illinois Institute of Technology, Northwestern University, and the University of Illinois, with participation by the University of Wisconsin and the Society of Motion Picture and Television Engineers.

FLEXLOC

SELF-LOCKING NUTS



STAY

TIGHT

AFTER

171,360,000

VIBRATIONS AT 4000 CYCLES PER MINUTE...

Plain nuts with lock washers loosened after only ONE HOUR of 4000-cycle-per-minute operation on the vibrator of a concrete block machine at the plant of the Bethayres Concrete Block Co., Bethayres, Pa.

When FLEXLOC Self-Locking Nuts were installed, they were *still tight* when the machine was torn down for rebuilding after 6 weeks operation—at 4000 C.P.M., 17 hours a day, 7 days a week!

If you have an application where nuts loosen or back off, try FLEXLOC, the one-piece, all-metal STOP- and LOCK-NUT "that won't work loose."

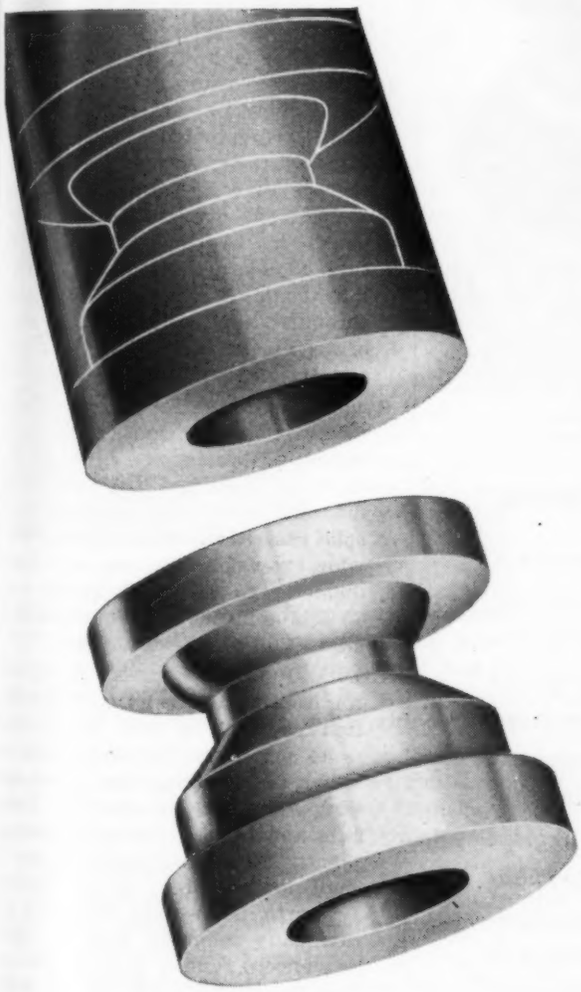
Send for Bulletin 619-A today.

—SPS—

STANDARD PRESSED STEEL CO.

JENKINTOWN 18, PENNSYLVANIA

How hollow-parts makers can save steel now



BY using Timken® seamless steel tubing instead of bar stock to make hollow cylindrical parts, you eliminate the drilling operation. This saves all the metal that's wasted in drilling a center hole in bar stock. You get more finished parts out of a ton of steel.

MOST ECONOMICAL SIZE TUBING

Still more steel is saved by the Timken Company's tube engineering service. Working with your specifications for your finished parts, we calculate the most economical size tubing for the job, *guaranteed* to clean up to your dimensions.

COST REDUCED, QUALITY IMPROVED

With Timken seamless steel tubing, finish boring is usually the first production step. Drilling is entirely eliminated. Machining time is saved. Costs are cut.

Quality is improved too, because the piercing process by which Timken tubing is made is basically a forging operation. This gives the tubing a uniform spiral grain flow for greater product strength and a refined grain structure that brings out the best in the quality of the metal.

UNIFORMITY ASSURED

Uniformity throughout the length of the tube is assured by the speed of the piercing process (one foot per second) which prevents heat loss. And rigid quality control from melt shop through final inspection maintains uniformity from tube to tube, heat to heat.

If you're looking for ways to save steel, cut costs and improve quality, ask for an "on the job" analysis by our Technical Staff. Write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

NEW USE

FOR FULLERGRIPT BRUSHES

Now Standard Equipment on Pratt & Whitney Vertical Die and Surface Grinders

On the new P & W Vertical Die and Surface Grinder a strip of Fullergript brush is mounted on the guard surrounding the grinding wheel. This continuous brush strip protects the operator from spray, and at the same time cleans the work of grinding grit, thereby eliminating scratches and improving finish. Here you find Fullergript brush strip as a component part of a Pratt & Whitney machine that produces ultra-smooth, accurate surface finishes — in a minimum of time. Fullergript was selected because the brush material — in this case abrasion-resisting nylon — is densely packed, and anchored, in a continuous, rust-resistant metal channel. This Fullergript strip can be formed into innumerable shapes and attached to stationary or power-driven mountings. If you have not discovered the cost-cutting or product-improving possibilities of Fullergript, why not send for our booklet, "Fullergript Power Brushes". Write to . . .

FULLER BRUSH

FULLERGRIPT

At home...in business, too

THE FULLER BRUSH CO.
INDUSTRIAL DIVISION
3647 MAIN STREET • HARTFORD 2. CONNECTICUT

New Machines

Manufacturing Equipment

WELDER: For light production, maintenance and repair welding. Model 25A has 6 heat stages, 20 to 100 amp output, welds metal 24 gage to $\frac{3}{16}$-in. thick, and handles rods $\frac{1}{16}$ to $\frac{1}{8}$-in. diameter. *Precision Welder Manufacturing Co., Chicago, Ill.*

BANDSAW: Features 60-in. throat frame. Welding unit joins bands to 2 in. wide, includes grinder and blade-squaring shear. Dial selects speed and feed; speeds from 40 to 10,000 fpm available. Work table has 16-in. hydraulic stroke; table tilts 45 degrees right, 10 degrees left. Upper guide post adjustable through 36-in. work height capacity of machine. Powered by 7½-hp motor. *Do-All Co., Des Plaines, Ill.*

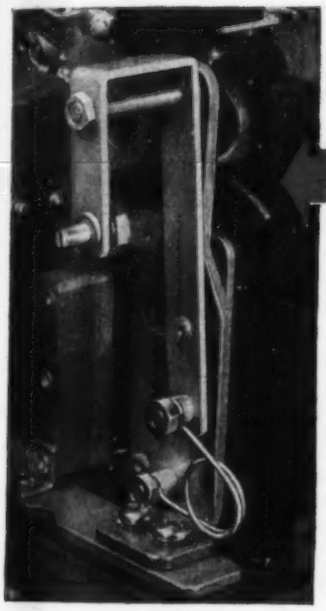
SURFACE GRINDER: Large rotary-table vertical-spindle grinder with 42-in. diameter abrasive wheel. Model 42-72-84 machine has magnetic 72-in. diameter work table machined from solid steel disk. Nonmagnetic 6-in. wide extension ring increases table diameter to 84 in. Equipped with 75 or 100 hp motor. *Blanchard Machine Co., Cambridge, Mass.*

SPECIAL-PURPOSE WELDER: Refrigerator back-panel welder with production capacity of over 200 welded units per hour. Includes table on which rear channel, back sheet and wrapper sheet are clamped. Table lifts until work contacts welding points. When required pressure is built up, welding cycle automatically starts. Sequencing units fire individually mounted guns in rapid sequence. Pressure on each gun adjustable through takeup nuts. *Thomson Electric Welder Co., Lynn, Mass.*

RADIAL DRILL: Capacity, 1¾ in. in mild steel; swing, 4½-ft. One motor for drilling and another for elevating power, both controlled by joystick type switch. Power supplied through collector rings which permit arm rotation through 360 degrees. Quick hand traverse, fine hand feed and automatic feed provided. Two ranges of 12 spindle speeds provided from 20 to 1800 rpm. *British Industries Corp., International Machinery Div., New York.*

ARBOR PRESS: Hand-operated 20-ton press for mounting buffs on polishing spindles or for general broach-

5 WALDES TRUARC RINGS ELIMINATE 4 TOOLING OPERATIONS... SAVE 22½¢ PER 100 UNITS

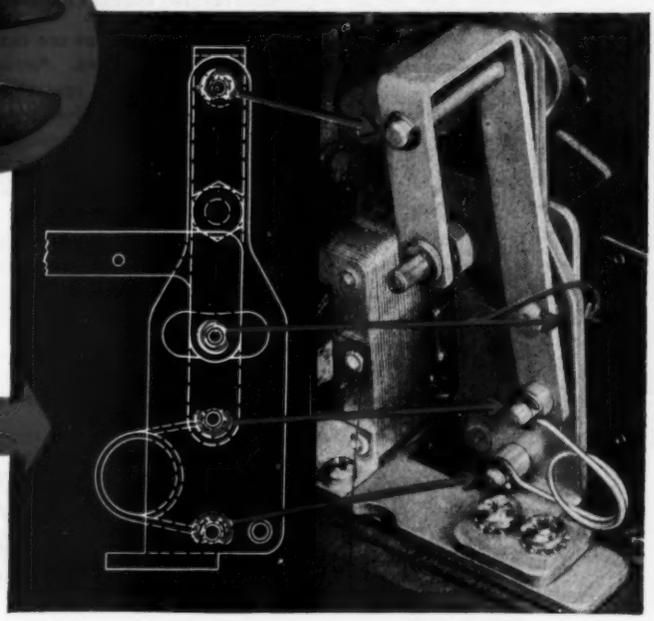


OLD WAY

Unit requires 4 hex head nuts, 4 washers, 4 shoulders, threading of 4 shafts. Clearance and end-play specifications necessary... constant maintenance.

NEW WAY

Just 5 Truarc "E" Rings set into predetermined grooves secure parts permanently. Assembly is simple, economical. No clearance specifications ...no maintenance!



5 Waldes Truarc Retaining Rings in one assembly of the Dictaphone Time-Master dictating machine brought great savings to Dictaphone Corp., Bridgeport, Conn. And this is just one of three different applications where Truarc Rings cut material, tooling and assembling costs for this product.

Redesign with Truarc Rings and you too will cut costs. Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better job of holding parts together.

Truarc Rings are precision-engineered...quick and easy to assemble and disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

Waldes Truarc Retaining Rings are available for immediate delivery from stock, from leading ball bearing distributors throughout the country.

REDESIGN WITH 5 TRUARC "E" RINGS BRING THESE BIG SAVINGS...

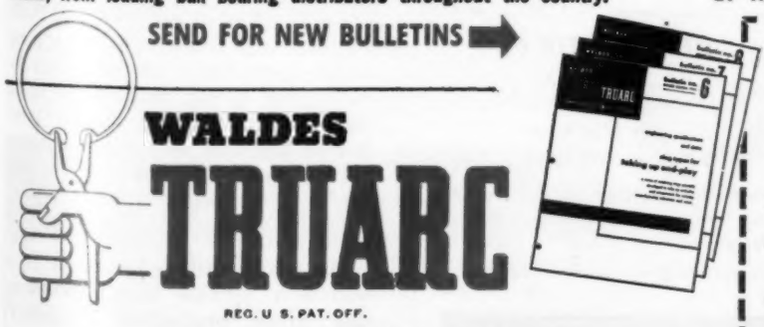
Assembly time per unit using screws and washers . 24 seconds

Assembly time per unit using Truarc Rings . . . . 15 seconds

- Time saved per unit with Truarc Rings . . . . . 9 seconds
- Eliminates skilled labor milling and threading operations
- Eliminates maintenance
- **TOTAL MATERIAL AND LABOR COST SAVINGS PER 100 UNITS . . 22½¢**

Be sure to see the Truarc display, Booths 215 and 216 at the Pacific Electronic Exhibit, August 22, 23, 24.

SEND FOR NEW BULLETINS



WALDES TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY THE FOLLOWING PATENT NUMBERS: U. S. PAT. 2,382,948; 2,420,921; 2,411,761; 2,487,803; 2,487,802; 2,491,306 AND OTHER PATS. PEND.

Waldes Kohinoor, Inc., 47-16 Austel Place MD083
Long Island City 1, N. Y.

Please send Bulletins 6, 7 and 8—giving engineering specifications for all types of Waldes Truarc Rings.

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone_____ State_____

678

Rynel

fractional h. p.

Gears

For All Small and Medium-Sized Gear Applications

Controlled Blank to Finished Gear

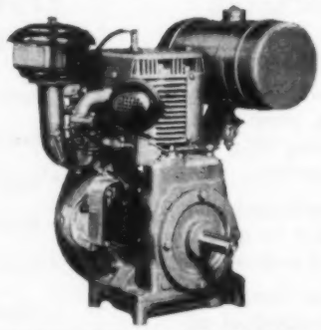
Rynel Certified Gears are made exactly to your specifications. Accuracy, tooth form and finish are controlled from the start with accurately formed blanks from our own gear blanking department. Experienced gear men cut true tooth forms with the latest precision equipment. Finished quality is checked by skilled gear inspectors. • That's why designers, engineers and product development men recognize Rynel Certified Gears for quality and dependability.

SPUR • HELICAL • WORM • WORM GEAR
INTERNAL • SEGMENT • SPROCKET • RATCHET
FINE PITCH • STRAIGHT-TOOTH BEVEL GEARS

Send For Our Latest Bulletin

Rynel Corporation
301 MILLER ST., STERLING, ILLINOIS

The POWER ADVANTAGE Story of the Model AEN Single-Cylinder WISCONSIN *Air-Cooled* ENGINE



Here's more power . . . less weight . . . lower cost . . . all with no sacrifice in heavy-duty construction and serviceability in this Model AEN single-cylinder Wisconsin Engine. Features include:

1. Dependable air-cooling under all climatic and weather conditions.
2. Self-cleaning tapered roller bearings at both ends of the crankshaft withstand either side-pull or end-thrust without danger to bearings.
3. Rotary type high tension OUTSIDE Magneto with Impulse Coupling operates as an entirely independent unit that can be serviced or replaced in a few minutes.
4. Maximum torque at usable speeds for equipment that really has to go to work.

Our engineering department will gladly cooperate with you in adapting Wisconsin Engines to your requirements. Write for detailed data and name of the nearest Wisconsin distributor.

CONDENSED SPECIFICATIONS

Bore	3"
Stroke	3¼"
Piston Displacement	23 cu. in.

HORSEPOWER

5.1 H.P. at 1800 R.P.M.
6.4 H.P. at 2200 R.P.M.
7.2 H.P. at 2600 R.P.M.
7.5 H.P. at 3000 R.P.M.

No. of Piston Rings	4
Fuel Tank Capacity	1.7 Gals

Weight, lbs.	Net	Crated
Standard Engine	110 lbs.	135 lbs.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46 WISCONSIN

ing, assembling, straightening, bending, etc. Has 5-in. ram travel. Framework inside dimensions, 17¼ by 60 in. *Clair Manufacturing Co., Olean, N. Y.*

MULTIPLE-SPINDLE DRILL PRESS: Heavy-duty production presses using standard 15-in. drill presses in combinations of 1 to 6 heads mounted on the same table. Feature self-aligning grease-sealed ball bearings, double-hinged guard and free-floating, 6-spline spindle. *Toolkraft Corp., Springfield, Mass.*

SPOT WELDING AND SOLDERING MACHINE: Resistance spot-welds and solders jewelry or other small parts. Welds steel parts up to $\frac{3}{32}$-in. thick, solders brass up to $\frac{1}{16}$-in. thick. Automatic cutoff timer regulates soldering time; heat control with 11 adjustments determines correct heat. Controlled soldering time eliminates burning, leaves no pitting marks. *Joyal Products Inc., Newark, N. J.*

SPRING COILER: Hand-operated machine for winding torsion, compression, extension or tapered springs, either right or left hand, in any length, with or without loops. Handles spring diameters up to 1½ in., wire sizes from 0.005 to 0.125-in. Pitch can be varied by single knob adjustment. Springs can be made with or without initial tension, with open or closed ends. *Perkins Machine & Gear Co., West Springfield, Mass.*

GRINDING MACHINES: Models 10 and 14-L plain hydraulic grinding machines have redesigned headstocks. Now powered by 1-hp a-c motors, eliminating d-c line to machine. Include built-in magnetic brake. Power transmitted entirely through V-belts; eccentric mechanism on primary countershaft provides belt tension adjustment and shifting. Machines include Filmatic bearings. *Cincinnati Grinders Inc., Cincinnati, O.*

TAPPING MACHINE: High-speed sensitive tapping machine can be operated by foot or air pressure. Built for use with single spindle tapping units or multiple heads with provision for quick changeover from job to job. Tapping action controlled through adjustable tension spring inside column. *Ettco Tool Co. Inc., Brooklyn, N. Y.*

BORING MACHINE: Horizontal boring, milling and drilling machine of 4 and 5-in. spindle sizes. Four-way bed gives production flexibility. Nonmetallic bearing surfaces used under saddle and table. Machines have range of 24 speeds; 8 to 1000 rpm in 4-in. size, 7 to 850 rpm in

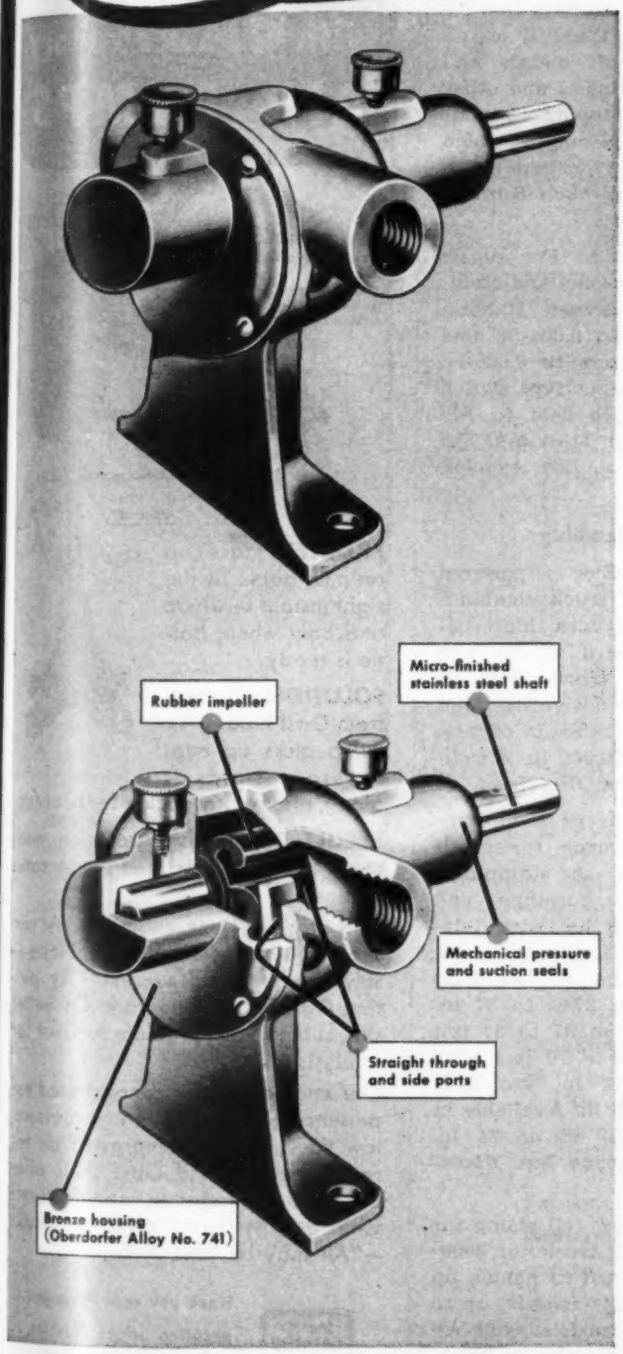
Since the OBERDORFER INTERNATIONAL Pumps described below are new, with no prior history of use, Washington expects a DEFENSE ORDER or equivalent for their purchase. Free samples are available to O.E.M. accounts.

New!

OBERDORFER INTERNATIONAL

Series IV

Rubber Impeller BRONZE PUMPS


Rubber impeller
Micro-finished stainless steel shaft
Mechanical pressure and suction seals
Straight through and side ports
Bronze housing (Oberdorfer Alloy No. 741)

These OBERDORFER INTERNATIONAL Series IV Rubber Impeller Bronze Pumps were designed to meet the demand for low pressure transfer pumps which could economically handle a high percentage of corrosive solids in suspension.

The Oberdorfer design has stressed port openings for obtaining maximum flow capacity while maintaining a wide area of wall support for the rubber impeller. This results in a highly efficient mechanism with a long service life when handling a very considerable list of contaminated liquids.

These pumps are self-priming to about 20 feet when the impeller blades are wet. Where possible a check valve should be installed on the suction side of the pump to insure constant pressure of the liquid being pumped about the impeller. Drive may be either clockwise or counterclockwise. Maximum pressures range between 20-30 p.s.i. The rubber impeller is keyed to the shaft and may be replaced in a matter of minutes.

CAPACITY TABLES — Gallons of water per minute— Outlet pressure in feet head and p.s.i.

Pump No.	Size	Ft. hd. p.s.i.	0 0	10 4.3	20 8.7	30 13.0	40 17.3	50 21.6	60 26	70 30
RA	½"		6½	6	5¼	4¼	3½	2½	1	—
RB	¾"		10¾	10	9	8	7	5½	4¾	2¼
RC	1"		21½	20	18½	17	15½	13½	11¾	8½

APPROXIMATE DIMENSIONS OBERDORFER INTERNATIONAL Series IV Pumps

Pump No.	Length	Width	Height
RA	5½"	4"	3⅜"
RB	6"	4¼"	4⅞"
RC	7⅛"	5"	5¾"

PRICE LIST OBERDORFER INTERNATIONAL Series IV Pumps

No. RA — $16.00	No. RB — $21.00	No. RC — $28.00

See our catalog in Sweet's File

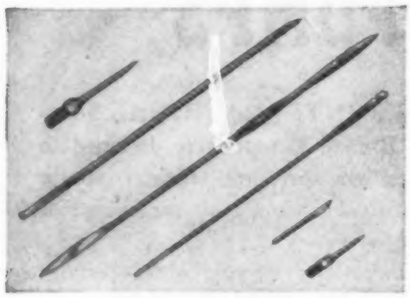
Write Dept. MD-518

INDUSTRIAL PUMP DIVISION
Oberdorfer Foundries, Inc.
Syracuse, N. Y.

CUT COSTS

have your metal parts precision-made by

TORRINGTON



Special equipment and volume production enable us to make precision parts for you at much lower costs.

For example, highest quality special needles for textile, leather, paper, etc., machinery. Pins for printing presses and surveyors' instruments. Special equipment assures proper heat-treatment . . . accurately formed eyes, grooves and shanks . . . precisely sharpened points . . . clean milling, knurling, slotting, and bevelling. Needles hand-straightened.

We are also set up to make such parts as knurled mandrels and spindles, screw driver and ice pick blades, instrument shafts and pivots, surgical and dental instruments, pen and pencil barrels, special rollers, studs, dowel pins, etc.

Send your prints and specifications today for a prompt quotation.

THE TORRINGTON COMPANY
Specialty Department
553 Field Street • Torrington, Conn.

Makers of
TORRINGTON NEEDLE BEARINGS

5-in. size. *The Bullard Co., Bridgeport, Conn.*

TAPPING-DRILLING MACHINES: High production tapping and drilling machines equipped with automatic air-controlled spindle heads and index tables. Multiple tapping performed direct from multiple drill head, without lead screws or clutches. Light air pressure permits taps to provide own lead. Class 2 and 3 fits obtained in soft metals and plastics, and in stainless and other steels. Multiple tapping accomplished with special motor which reverses taps when desired depth is reached. *The Beckett-Harcum Co., Wilmington, O.*

PORTABLE SPOT WELDER: For repair and alteration of Inconel and stainless steel foil and screen. Handles foil thickness up to 0.004-in. and screen wire diameters to 0.020-in. Operation is by trigger type switch with both electrodes held to foil surface. Operates on 110-v a-c. *The H. I. Thompson Co., Los Angeles, Calif.*

Materials Handling

INDUSTRIAL TRUCK: Electric-powered materials handling truck combines low truck weight with high capacity. Uses forward wheels and axles of platform truck, arms as in fork truck. New design has high capacity-to-weight ratio. In capacities from 4000 to 10,000 lb. *Elwell-Parker Electric Co., Cleveland, O.*

CONVEYOR: Permanent or semipermanent power conveyor for small metal parts such as stampings, castings, borings, turnings and chips. In five lengths, with telescoping legs permitting vertical adjustment: discharge of 4-ft long size variable from 27½ to 37 in. high; 6-ft size, from 37 to 57 in.; 8-ft size, from 40 to 70 in.; 10-ft size from 48 to 87 in; and 12-ft size, from 56 to 96 in. Available in belt widths of 12, 18 or 24 in. *May-Fran Engineering Inc., Cleveland, O.*

ROLL CLAMP: Rotating roll clamp for attachment to fork trucks of 2000-lb capacity. Designed to handle up to 1500 lb on "2024" models, up to 950 lb on "2015" models. Unit rotated through 90 degrees by cylinder with chain and scrocket linkage, with positive stops at vertical and horizontal positions. Max clamping force, 5000 lb. Manually-operated relief valve is standard equipment. *Clark Equipment Co., Industrial Truck Div., Battle Creek, Mich.*

ELECTRIC FORK TRUCKS: Line of light-capacity trucks in sizes to 2000-lb capacity. Feature automotive type

SOLVED:
an unusual FEEDING PROBLEM- with GAST rotary AIR PUMPS

This machine by Basca Manufacturing Company, Inc., puts Econ-O-Seal aluminum caps on milk bottles in dairies.

PROBLEM: Place cap on milk bottle at the right instant — when, and *only* when, bottle is ready.

SOLUTION: Suction from Gast Rotary Air Pump picks up cap. Pressure sends it along, also returns sucker for next cap.

RESULT: Dependable operation, moderate cost for pump, long-term satisfaction.

And that's but one example. We can show you scores of other problems — solved with equal success — by putting Gast Rotaries to work. Or better still, submit *your* problem to Gast for analysis.

Our engineers offer concentrated experience on the uses of low pressure, low vacuum, and compressed air for rotary power. And Gast Units offer unique advantages to manufacturers who "Specify Gast." Write for details —"Air may be your Answer!"

see our CATALOG in SWEET'S FILE for product designers

Have you seen Gast Application Ideas booklet, showing 26 product problems and solutions? Sent on request.

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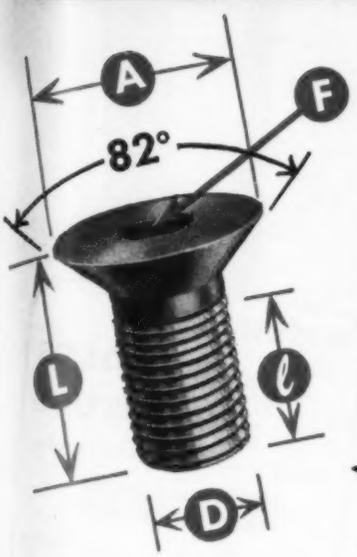
FLAT HEAD SOCKET CAP SCREWS

Class 3 fit is an "UNBRAKO" standard



Diameter	Threads per inch NC	Threads per inch NF	Overall Length L	Thread Lengths ℓ NC	Thread Lengths ℓ NF	Price per 100	Quantity per box
#4	40		¼	¼		5.15	100
(.112")	40		⅜	⅜		5.35	100
A .225"	40		½	½		5.55	100
F ¼"	40		⅜	⅜		5.75	100
	40		¾	¾		5.95	100
#6	32		¼	¼		5.35	100
(.138")	32		⅜	⅜		5.55	100
A .279"	32		½	½		5.75	100
F 5⁄16"	32		⅜	⅜		5.95	100
	32		¾	¾		6.15	100
#8	32		⅜	⅜		5.65	100
(.164")	32		½	½		5.85	100
A .332"	32		⅜	⅜		6.05	100
F 3⁄8"	32		¾	¾		6.25	100
	32		1	27⁄32		6.55	100
#10	24	32	⅜	⅜	⅜	5.75	100
(.190")	24	32	½	½	½	5.95	100
	24	32	⅝	⅝	⅝	6.15	100
	24	32	¾	¾	¾	6.35	100
A .385"	24	32	1	1	1	7.10	100
F 1⁄8"	24	32	1¼	31⁄32	27⁄32	7.85	100
	24	32	1½	31⁄32	27⁄32	8.50	100
1/4	20	28	⅜	⅜	⅜	6.00	100
(.250")	20	28	½	½	½	6.25	100
	20	28	⅝	⅝	⅝	6.50	100
	20	28	¾	¾	¾	6.75	100
A 1⁄2"	20	28	1	1	1	7.50	100
	20	28	1¼	1¼	15⁄16	8.25	100
F 3⁄32"	20	28	1½	13⁄32	15⁄16	9.00	100
	20		1¾	13⁄32		9.75	100
	20		2	15⁄32		10.50	100
5/16	18	24	⅜	⅜	⅜	6.75	100
(.3125")	18	24	½	½	½	7.00	100
	18	24	⅝	⅝	⅝	7.25	100
	18	24	¾	¾	¾	7.50	100
A 5⁄8"	18	24	1	1	1	8.50	100
	18	24	1¼	1¼	1¼	9.25	100
F 3⁄16"	18	24	1½	13⁄4	1 1⁄16	10.00	100
	18		1¾	13⁄16		10.75	100
	18		2	13⁄4		11.50	100
	18		2¼	13⁄4		12.25	100
	18		2½	123⁄64		13.00	100
3/8	16	24	½	½	½	7.50	100
(.375")	16	24	⅝	⅝	⅝	8.00	100
	16	24	¾	¾	¾	8.50	100

Diameter	Threads per inch NC	Threads per inch NF	Overall Length L	Thread Lengths ℓ NC	Thread Lengths ℓ NF	Price per 100	Quantity per box
3/8	16	24	1	1	1	9.75	100
(.375")	16	24	1¼	1¼	1¼	10.75	100
	16	24	1½	1½	1⅛	12.00	100
A 3⁄4"	16		1¾	1⅜		13.00	100
	16		2	1⅜		14.00	100
F 7⁄32"	16		2¼	1⅜		15.00	100
	16		2½	1¼		16.00	50
	16		2¾	1⅜		17.00	50
	16		3	1½		18.00	50
7/16	14		¾	¾		10.50	100
(.4375")	14		1	1		12.00	100
	14		1¼	1¼		13.00	100
	14		1½	1½		14.25	100
A 13⁄16"	14		1¾	1¾		15.25	100
	14		2	1 17⁄32		16.25	50
F 1⁄4"	14		2¼	1 17⁄32		17.50	50
	14		2½	1 17⁄32		18.75	50
	14		2¾	1 17⁄32		20.00	50
	14		3	1½		21.50	50
1/2	13	20	¾	¾	¾	12.00	100
(.500")	13	20	1	1	1	13.25	100
	13	20	1¼	1¼	1¼	14.50	100
	13	20	1½	1½	1½	15.75	100
A 5⁄8"	13	20	1¾	1¾	1 11⁄32	17.00	50
	13	20	2	1 19⁄32	1 11⁄32	18.25	50
F 5⁄16"	13		2¼	1 19⁄32	1 11⁄32	19.75	50
	13		2½	1 19⁄32	1 11⁄32	21.25	50
	13		2¾	1 19⁄32	1 11⁄32	23.00	50
	13		3	1 19⁄32	1 11⁄32	25.00	50
5/8	11		1¼	1¼		21.00	50
(.625")	11		1½	1½		23.00	50
	11		1¾	1¾		25.00	50
	11		2	2		27.00	50
A 1 1⁄8"	11		2¼	2¼		29.00	25
	11		2½	1 15⁄16		31.00	25
F 3⁄8"	11		2¾	1 15⁄16		33.00	25
	11		3	1 15⁄16		35.00	25
3/4	10		1¼	1¼		26.00	50
(.750")	10		1½	1½		28.50	25
	10		1¾	1¾		31.00	25
	10		2	2		33.50	25
A 1 3⁄8"	10		2¼	2¼		36.00	25
	10		2½	2½		39.00	25
F 3⁄8"	10		2¾	2½		42.00	25
	10		3	2½		45.00	25

Maximum head contact, flush surface finish and non-slip internal wrenching make these high - tensile screws ideal for the assembly of thin-section materials.

Prices subject to change without notice.

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Standard UNBRAKO thread lengths are computed from the following formulas:

"**Thread Length,** 1.—A screw thread is measured from the extreme point to the last usable thread and shall be as follows:

For American National coarse.

$\ell = 2D + \frac{1}{2}''$ (where this length of thread would be greater than half the screw length).

$\ell = \frac{1}{2}L$ (where this length of thread would be greater than $2D + \frac{1}{2}''$).

For American National fine.

$\ell = 1\frac{1}{2}D + \frac{1}{2}''$ (where this length of thread would be greater than three-eighths the screw length).

$\ell = \frac{3}{8}L$ (where this length of thread would be greater than $1\frac{1}{2}D + \frac{1}{2}''$).

Screws too short to allow application of these formulas shall be threaded as close to the head as practicable."

(Quoted from National Bureau of Standards Handbook H-28)

★ One of a series listing *Standard* UNBRAKO Socket Screw Products sold by your local UNBRAKO Distributor. If you want reprints of this and other advertisements in the series, ask for them on your business letterhead.

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controls, hydraulic lift and compact size. Magnetic contactor control provides time delay between speeds for smooth acceleration. Mast tilted forward hydraulically 5 degrees, backward 10 degrees. Specifications of 2000-lb model: overall height, 83 in.; primary lift, 19¼ or 69 in.; weight, 4280 lb with battery; speed, 6½ mph. *The Yale & Towne Manufacturing Co., Philadelphia Div., Philadelphia, Pa.*

TROLLEY HOISTS: In capacities from ½ to 3 tons. In two-wheeled plain trolleys or one plain and one geared two-wheeled trolley. Plain trolley assembly has tread wheels equipped with ball bearings, steel side plate and connections to load bar. Geared trolley has wheels with gear rings with cut teeth, pinions with cut-teeth handwheel, hand chain and hand chain guides. *Wright Hoist Div., American Chain & Cable Co., Inc., York, Pa.*

ELECTRIC FORK TRUCK: Rider-driven unit for small plants. New telescoping sections for raising forks require less power than conventional systems. Specifications: standard minimum height, 83 in.; free lift, 63 in.; max fork lift, 126 in.; capacity 2000 lb at 15-in. centers; full-load speed, 3 mph; no-load speed, 3.5 mph. Mast and carriage control is of dead man type to prevent operation of machine when unattended. *Market Forge Co., Everett, Mass.*

OVERHEAD CONVEYOR: Light-capacity, power-driven overhead chain conveyor handles 30-lb loads at 6-in. centers or 60-lb loads at 12-in. centers when supported by two pendents fitted with crossbar attachment. Sprocket type drive used to distribute chain stresses and give straight-line pull in either direction. Variable-speed drive adjustable from 3 to 9 fpm; other speed ranges available. Conveyor negotiates curves with radii as short as 15 in. *Southern Engineering Co. Inc., Burbank, Calif.*

FORK TRUCK: Heavy-duty Yardlift-150 for outdoor work. Capacity, 15,000 lb. Pneumatic-tired unit for lumber mill yards, steel warehouses and fabrication plants, scrap handling plants, building supply yards, etc. Easy steering accomplished by 22-in. diam wheel operating hydraulic power steering control; in case of engine stoppage, truck can be steered mechanically. *Clark Equipment Co., Industrial Truck Div., Battle Creek, Mich.*

TRACTOR: New 12,000-lb drawbar pull tractor for airline, railroad, industrial or military pushing and pulling

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37 years' experience in making special bolts, studs, nuts for specific job requirements.

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special gasketing that both seals and conducts high frequency currents. It makes an air-tight seal and yet prevents leakage of high frequencies between the bolt holes.

Cohrlastic conductive gasketing provides a continuous mounting and minimizes high frequency losses that affect radio operation.

It is widely used in aircraft (1) between the magnetos and their bases, (2) in the ignition harness, (3) in quick disconnect plugs and (4) wherever shielding is required.

Cohrlastic conductive gasketing is available in three different thicknesses—.016", .020" and .028" in rolls 8" wide and in the finished gaskets on a custom basis. Write for samples, prices and data sheets.

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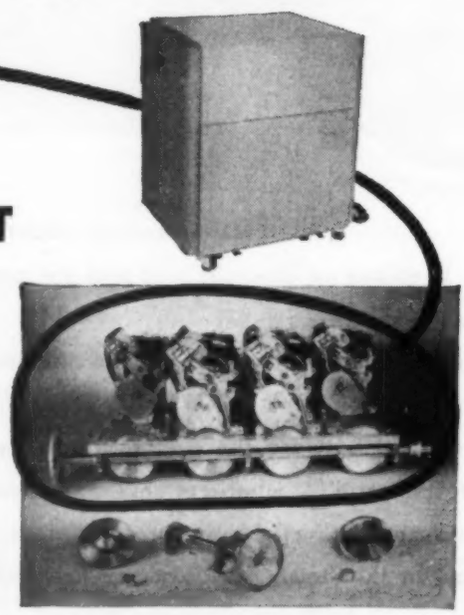
Mass. G&T Gear

APPLIED in

I.B.M. ELECTRONIC CALCULATOR "MEMORY" UNIT



In the Auxiliary "Memory" Unit of the International Business Machines Card-programmed Electronic Calculator, two sub-assemblies employ eight face gears and eight pinion gears. These gears and pinions are made by "Mass. Gear."

●

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work. Incorporates single-stage, closed-circuit type torque converter to eliminate starting shocks and excessive strain. Powered by 6-cylinder, 230 cu in. Buda gasoline or diesel engine. Includes 4-wheel hydraulic brakes, four forward and one reverse speeds, dual pneumatic drive tires. Torque multiplication at stall speed, 2.2 to 1. *The Buda Co., Harvey, Ill.*

ELECTRIC PALLET TRUCK: Rider type low-lift truck for single and double-face pallets. Designed to speed up handling by enabling operator to ride. Travels at 6 mph empty, at 5 mph with capacity load of 4000 lb. Can right-angle pick up or spot loads from 6-ft wide aisles. With carrying frames 30 to 60 in. long, widths of 24, 27 or 30 in. Overall length of power unit and riding areas combined, 28 in. *Lyon-Raymond Corp., Greene, N. Y.*

TRACTOR: Model 3600 tractor for indoor trailer hauling. Drawbar pull, 2000 lb. Powered by 13-hp Wisconsin engine through automotive type clutch and three-speed and reverse transmission. Loading space of 11 sq ft provided on tractor. Includes flame-proof muffler with spark arrestor on tail pipe. Max speed, 10 mph. *Kalamazoo Manufacturing Co., Kalamazoo, Mich.*

ADJUSTABLE CONVEYOR: Lightweight Adjustoveyor has 850-lb total capacity, max unit weight capacity of 300 lb. Portable unit is counterbalanced, mounted on wheels. Adjustable from 10 to 17½ ft, will stack to height of 10 ft at max stacking angle of 30 degrees. Includes 14-in. wide rough-top rubber belt on 18½-in. ball-bearing mounted rolled bed. Conveyors powered by ½ or ¾-hp motors. *Stewart-Glapat Corp., Zanesville, O.*

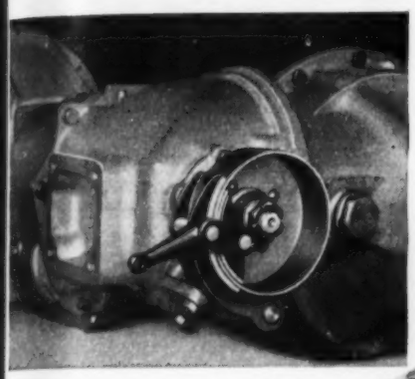
SPARK-ENCLOSED FORK TRUCK ENGINES: Designed to provide max safety operation in gas and dust laden areas. Protection accomplished by shielding electrical equipment against sparking, by providing water type exhaust manifold by water-cooled muffler, and by using static-conductive tires. Available on Yale gasoline fork trucks. *The Yale & Towne Manufacturing Co., Philadelphia, Pa.*

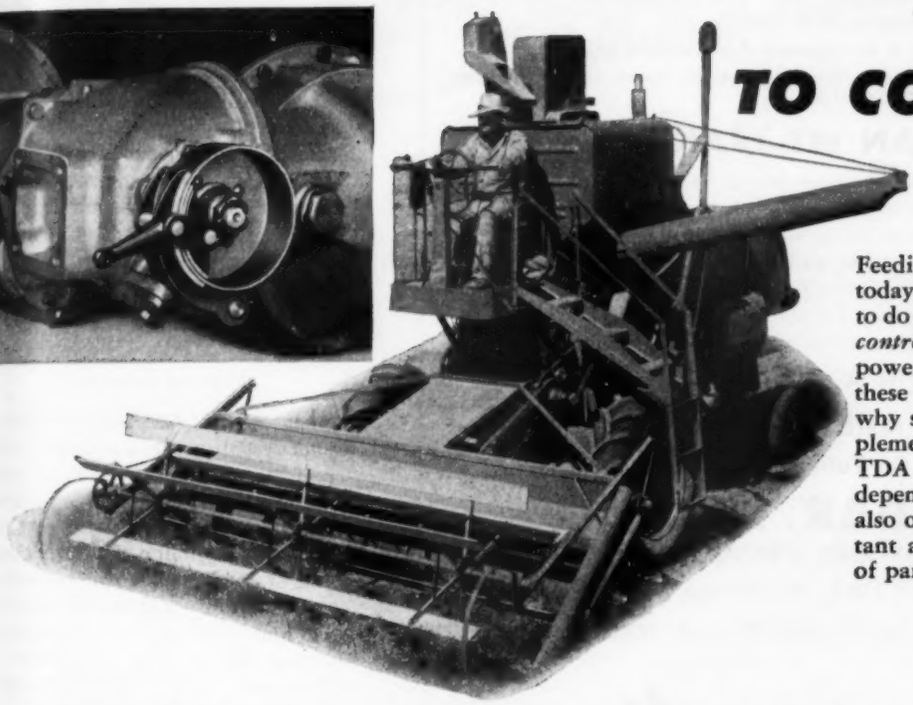
ELECTRIC FORK TRUCKS: New 4000 and 5000-lb Carloaders have control lever on steering column for simplified operation. Include automatic acceleration and steering through axle pivoted on rubber torsional springs to eliminate kickback. *Clark Equipment Co., Industrial Truck Div., Battle Creek, Mich.*

FORK TRUCK CLAMP: Hydraulically

The Farmer's Fastest-Working "Hired Hand"!

-BUT HE NEEDS BRAKES





TO CONTROL IT!

Feeding America is a big job! And today's farmer needs modern tractors to do it! For the most part, tractors are *controlled* by brakes! It takes rugged, powerful brakes to steer, stop and hold these hard-working machines. That's why so many leading tractor and implement manufacturers standardize on TDA Brakes. Well-known for safe, dependable operation, TDA Brakes also offer the tractor user such important advantages as ready accessibility of parts and ease of maintenance.

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It's hard to name a machine in industry or commerce that doesn't have rotating parts! And *useful* rotation is *controlled* rotation! In most instances, that's a job for brakes—strong, dependable *TDA Brakes!* These advance-designed brakes are the result of TDA's more than 40 years of braking experience combined with the skill and know-how of highly competent technicians and engineers. If you have a braking problem—regardless of its nature and scope—contact TDA Brake Division! They'll be glad to analyze your brake needs and supply equipment precisely engineered for your specific purposes. Simply mail the coupon below!

Here Are A Few Of The Many Products Which Can Be Equipped With TDA Brakes

Centrifuges • Compressors • Conveyors • Cranes Cream separators • Diesel hook-ups • Dry cleaning machinery • Extractors • Hoists • Industrial electric trucks • Lathes (automatic) • Looms (textile) • Lumber mill machinery • Machine tools • Materials handling equipment • Motors • Packaging machinery • Paint mixers • Press brakes • Printing presses • Rolling mills • Shears • Warpers (textile) • Welding positioners • Winches • Automotive • Farm equipment Earth moving equipment • Construction equipment Public transportation

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They are furnished as standard equipment on leading makes of engines, and machinery. Or they can be installed on your present equipment.

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Manzel 276 BABCOCK STREET BUFFALO, NEW YORK

operated rotating clamp for handling bales, bins, drums, and other containers. Self-centering clamps prevent off-center load. Variable clamping pressure permits handling any type load without damage to material. Arms have inside opening range from 17 to 66 in., will handle loads to 6000 lb. *The Yale & Towne Manufacturing Co., Philadelphia, Pa.*

ELECTRIC LIFT TRUCK: SpaceMaster "61" heavy-duty, high-speed unit designed especially for warehouse work requiring minimum operating space. Will carry and high stack 3000-lb load 48-in. long. Pallets 40-in. long can be right-angle stacked in 10-ft aisle. Lift mast design gives 127-in. fork elevation, 65¼-in. free lift, 83-in. collapsed height. Designed to require no lubrication. *Lewis-Shepard Products Inc., Watertown, Mass.*

Plant Equipment

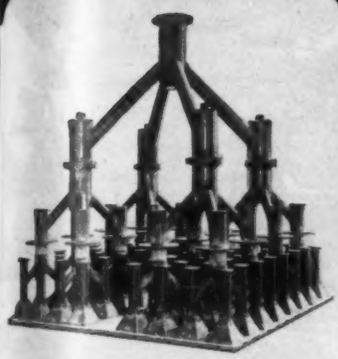
CONCRETE VIBRATOR: Designed to compact freshly-poured concrete and direct its movement as it is poured in form. Model No. 521 pneumatic vibrator consists of 2¾-in. diameter steel cylinder 17½ in. long at end of combination air and exhaust hose. Includes adjustable automatic air line oiler, roll type throttle providing up to 8000 vibrations per minute. *Independent Pneumatic Tool Co., Aurora, Ill.*

BATTERY CHARGER: For industrial trucks. Handles units up to 55 amp-hour capacity. Operates on selenium rectifier principle, with no moving parts. Automatic controller gives easy operation, simplified maintenance and decreased power requirements. Available for either lead-acid or nickel-alkaline batteries. Can be plugged into standard 110-volt 60-cycle outlet; step-down transformer furnished for 220-volt outlets. *The Yale & Towne Manufacturing Co., Philadelphia, Pa.*

TORQUE-INDICATING DRIVER: Automatically measures torque on studs, nuts, screws or other fasteners. Built around standard deflection type torque wrench; minimum torque indicated by green light, max torque indicated by red light. Relay can be supplied to interrupt power when desired max torque is reached. In zero to 100, 350, 500, 750, 1500 and 2000 in-lb capacity sizes. Electric standard or high-cycle motors or air motors can be specified. *Tru-Circle Products Co., South Bend, Ind.*

STRAPPING CUTTER: Hand-operated cutter for steel strapping is operated with one hand. Cuts ¾ by 0.050-in. steel strapping; designed

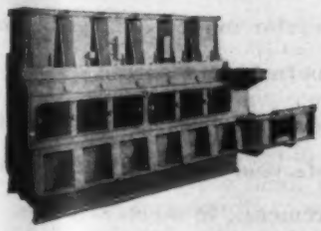
Steel-Weld FABRICATION



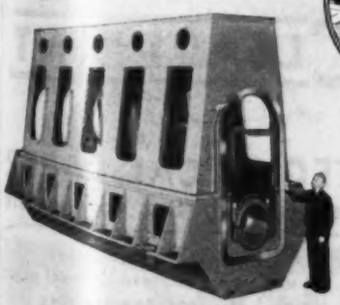
One of Several Parts of a Catalytic Cracking Plant Produced for the Petroleum Industry.

Pressure Vessels for the Chemical and Allied Industries.

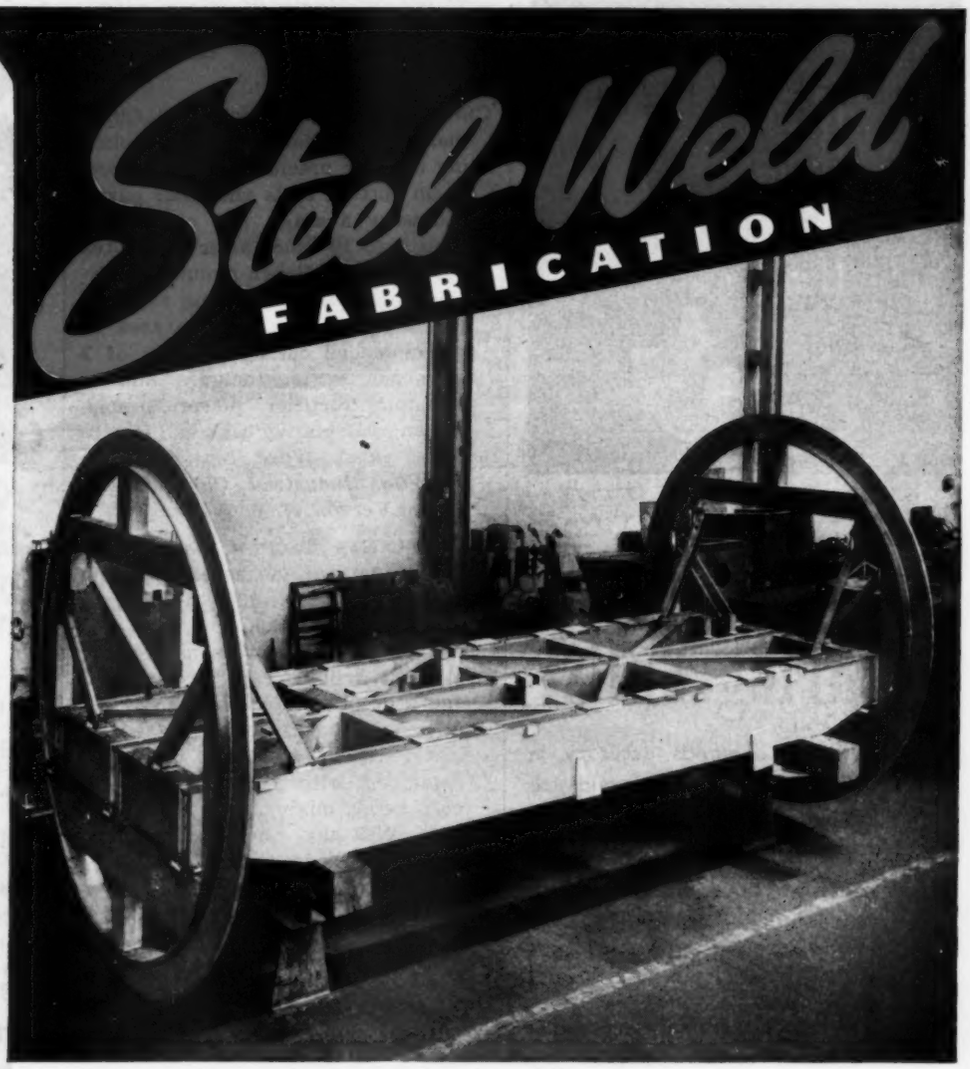
Heavy Press and Machine Frames and Bases for the Machine Tool Industry.



Diesel Engine Crank Cases and Frames for the Marine and Electro-Motive Field.



Crank Cases, Frames, and other Parts for Manufacturers of Marine Steam Engines of Uniflow or Multiple Expansion Type.



Use WELDED STEEL for Greater Strength with Less Weight!

The Steel-Weld Fabricated Roll-Over Fixture illustrated above, with end frames eleven feet in diameter, is another excellent example of a unit which could not be economically produced by any other method . . . it is typical of thousands of heavy machinery parts and assemblies produced by Mahon for many manufacturers. If savings in either time or cost can be effected in your operations through Steel-Weld Fabrication of parts or fixtures, or if you are cramped for manufacturing space, it will pay you to investigate Mahon facilities. You will find an unique source with complete, modern fabricating and machining facilities for any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures you a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

to get under tightly bound strap. Model 34 unit measures 9 in. long, weighs ¾-lb. *Manco Manufacturing Co., Bradley, Ill.*

CHROME PLATER: Model A-50 Chromaster industrial hard chrome plating unit for precison plating directly on cutting tools and wear parts. Increases average life of cutting tools 2 to 10 times after 3 minutes plating time. Bench-mounted, self-contained unit has plating capacity of 25 sq in. max surface area at recommended current density of 2 amp per sq in. Includes built-in selenium rectifier power supply, rectangular plating tank and instrument panel. *Ward Leonard Electric Co., Industrial Chrome Div., Mount Vernon, N. Y.*

NATURAL GAS ENGINE: Designed to run on natural gas in oil-producing areas. Model LR-600-GAS engine rated 315 hp at 1100 rpm. Designed principally to provide power for oil well drilling rigs. Six-cylinder, spark ignition engine has 2477-cu in. displacement, weighs 7500 lb, has 6.8:1 compression ratio. Equipped with air starting, gas carburetor, mixing valve, and magneto. Will also run on commercial Butane on addition of vaporizing and regulating attachment. *Cummins Engine Co. Inc., Columbus, Ind.*

Processing Equipment

TUMBLING MACHINE: Pushbutton operated machine with all controls on one panel. Provided with jogging control and magnetic reversing starter with 110-volt control transformer. Automatic timer adjustable to 20 hours, shuts machine off after preset time. Powered by 5-hp variable-speed power unit with remote-control handle for varying cylinder speed from 10 to 30 rpm. Safety switch stops machine when gate is raised. Cam locks on doors have spring-loaded pressure releases to prevent excessive pressure build-up in cylinder. Each of two compartments has 18 cu ft capacity. *Roto-Finish Co., Kalamazoo, Mich.*

Testing and Inspection

METAL DETECTORS: For location of metallic particles in bakery products, meat, candy, plastics, paper, rubber, etc. Products pass through inspection aperture on endless belt at 10 to 1000 fpm. Contaminants cause lamp to light, bell to ring, or belt to stop. Four inspection heads include 2½ by 7½-in. and 4 by 5-in. rectangular sizes, 1⅛ and 2-in. diameter sizes. *RCA Victor Div., Radio Corp. of America, Camden, N. J.*

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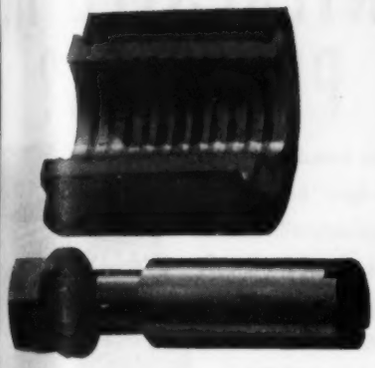

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TESTING MACHINE: Low-cost universal testing machine; capacity, 12,000 lb. Has hydraulic loading unit separate from indicating and control unit. Gripping heads have 8-in. stroke; machine has 9½-in. clear lateral space between columns. Includes two ranges: 12,000 range graduated in 20-lb units on 16-in. diameter dial; 3000-lb range graduated in 5-lb units; other ranges available. Accurate to 1 per cent or one dial division, whichever is greater. *Baldwin-Lima-Hamilton Corp., Philadelphia, Pa.*

COUNTER: For general purpose counting, including total count, rate of count, and predetermined count. Can count at rate of over 10,000 units per second through use of photocell and electronic circuits. Counter automatically energizes external circuit at end of predetermined count to segregate batches. Visual 6-digit totalizer indicates exact count; rate meter shows rate of count per hour. Unit may be located up to 75 ft from photocell head. *The Post Machinery Co., Beverly, Mass.*

BRINELL HARDNESS TESTER: Incorporates 24-in. throat depth. Hydraulically operated unit is mounted on wheels, has lower anvil as top of hydraulic piston which automatically raises as load is applied to take pressure off conveyor. Max vertical opening between ball penetrator and anvil, 4 in. Overall dimensions, 19 in. wide by 41 in. deep; weight, 900 lb. *Steel City Testing Machines Inc., Detroit, Mich.*

Woodworking Equipment

POWER HAND SAW: New 8-in. power saw cuts 2⅝ in. deep on square cut, 2 3/16 in. on 45-degree cut. Weight, 14 lb. Includes diecast aluminum frame, universal 115-v motor, no-load speed of 4600 rpm. Equipped with double pole, momentary contact switch with 100 per cent overload capacity. Safety guard is telescopic type with quick return. *Fred W. Wappat Div., Cummins Portable Tools, Mayville, N.Y.*

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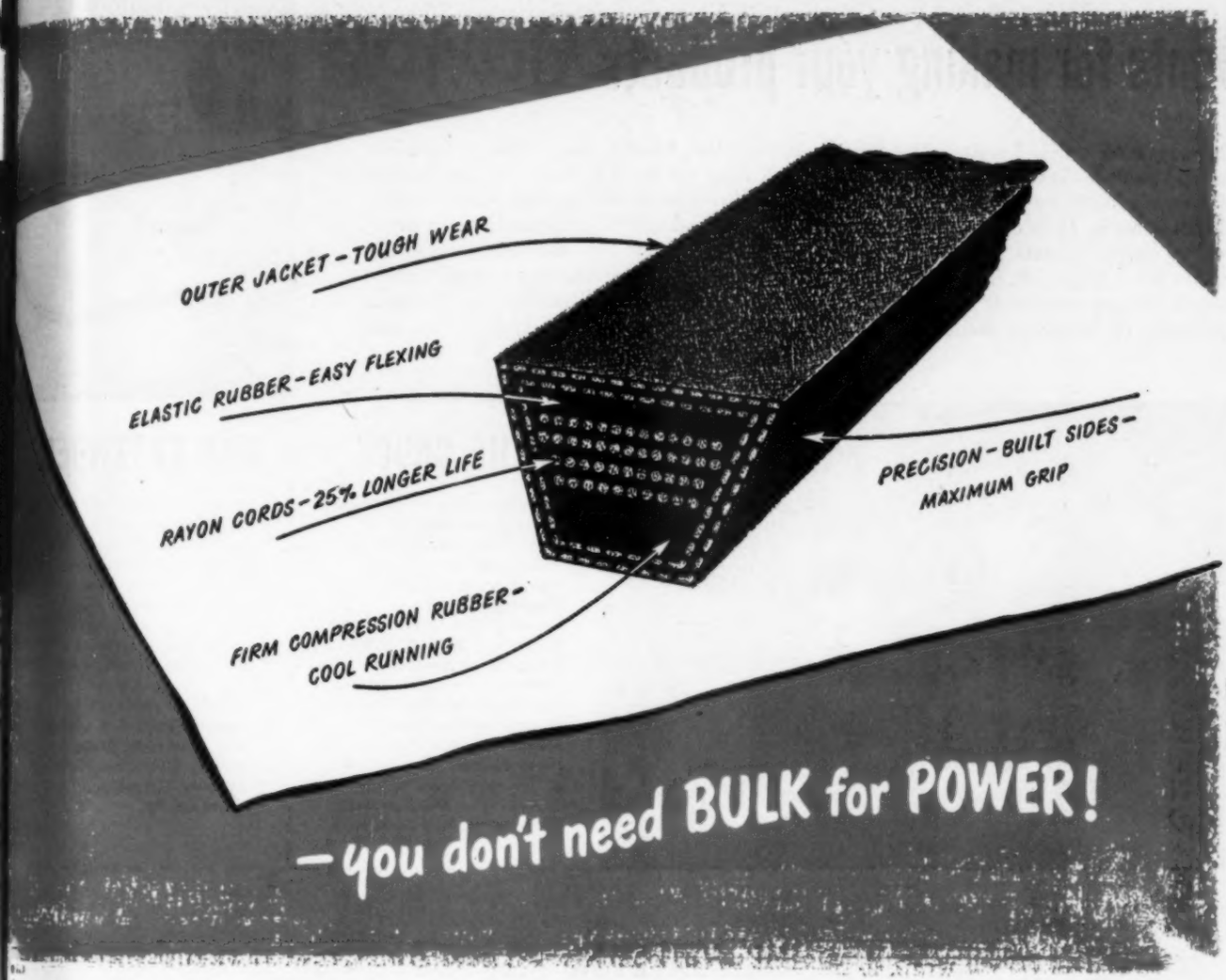
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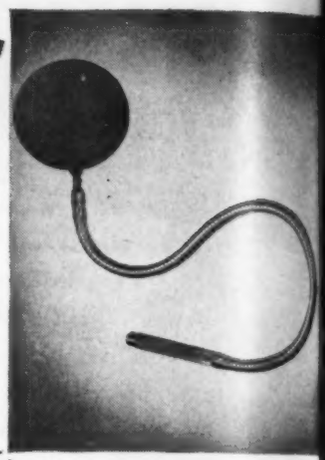

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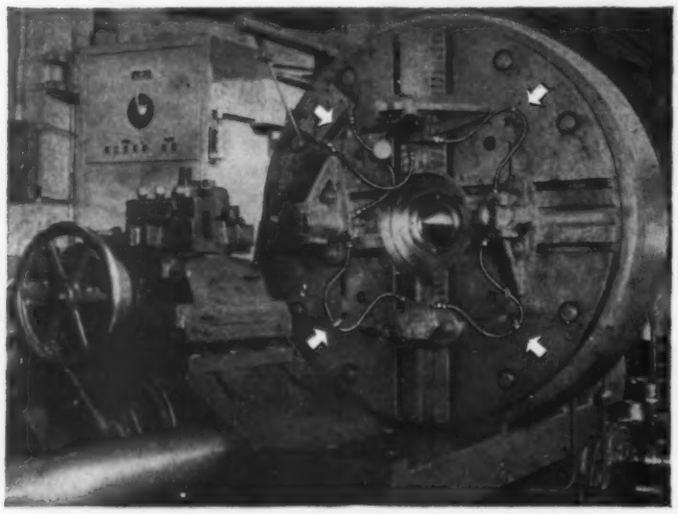

LATHE CHUCK

This giant lathe chuck holds railroad car wheels. To exert equal pressure on the wheel rim, five sets of American Seamless Bronze Flexible Tubing carry hydraulic fluid to each of the five driving dogs. This is a typical example of the combined strength, tightness and flexibility which characterize American Flexible Metal Hose and Tubing. Photo courtesy Wm. Sellers & Company Division, Consolidated Machine Tool Corporation, Rochester, N. Y.

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Here's a handy gadget for oil burner and air conditioning installers and repair men—an inspection mirror on a flexible arm utilizing American $^{7}/_{32}$" Flexible Steel Tubing. Adjusts to any position of the familiar "gooseneck" lamp arm, for which millions of feet of this American Lamp Arm Tubing have been used. Photo courtesy Eddington Metal Specialty Company, Eddington, Pa.

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